PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 22 February 2001 (22.02.01)	
International application No. PCT/GB00/02057	**Applicant's or agent's file reference** DE/J088404PWO
International filing date (day/month/year) 26 May 2000 (26.05.00)	**Priority date** (day/month/year) 28 May 1999 (28.05.99)
Applicant FLETCHER, Jonathan, Bridge et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

21 December 2000 (21.12.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Juan Cruz
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

EVERY, David Aidan
MARKS & CLERK
Sussex House
83-85 Mosley Street
Manchester M2 3LG
GRANDE BRETAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	30.08.2001
Applicant's or agent's file reference DE/J088404PWO	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02057	26/05/2000	28/05/1999

Applicant
CARTER BROS (ROCHDALE) LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Langhoff, M Tel.+49 89 2399-8221

PATENT COOPERATION TREATY

PCT

10/031050 U.S.

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
DE/J088404PWO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 00/02057	26/05/2000	28/05/1999
Applicant		
CARTER BROS (ROCHDALE) LTD. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 6 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any ***nucleotide and/or amino acid sequence*** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [X] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 2

   [ ] as suggested by the applicant.

   [X] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

- line 6: ... leading face (17) of the first portion (12)...
- line 7: leading face (19).. second portion (13)... length of a tip (W1, W2)..

INTERNATIO SEARCH REPORT

International application No.
PCT/GB 00/02057

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-15,17

mixing chamber with two rotors rotating in opposite directions, at least one of the rotor having an axially extending projection with a leading face. The leading face has a discontinuity: the first portion being concave and the second portion being convex.

2. Claim : 16

mixing chamber with two rotors rotating in opposite directions, at least one of the rotor having an axially extending projection. The tip defines a circumferential surface forming at least 5% of the circumference of the rotor. The clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

INTERNATIONAL SEARCH REPORT

International Application No
GB 00/02057

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29B7/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y X	EP 0 170 397 A (SHAW PLC FRANCIS) 5 February 1986 (1986-02-05) abstract; figures	1-14,17 15
Y	US 4 914 635 A (NISHIGAI KAZUHISA ET AL) 3 April 1990 (1990-04-03) abstract; figures	1-13,17
Y X	EP 0 848 988 A (KOBE STEEL LTD) 24 June 1998 (1998-06-24) column 10, line 25 - line 57; figures 1,11	14 16
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 10, 31 October 1996 (1996-10-31) & JP 08 142046 A (BRIDGESTONE CORP), 4 June 1996 (1996-06-04) abstract	1-3, 11-13

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

'A' document defining the general state of the art which is not considered to be of particular relevance

'E' earlier document but published on or after the international filing date

'L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

'O' document referring to an oral disclosure, use, exhibition or other means

'P' document published prior to the international filing date but later than the priority date claimed

'T' later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

'X' document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

'Y' document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

'&' document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 November 2000	05. 12. 00

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Belibel, C

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
GB 00/02057

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 1 936 248 A (LASCH A. ET AL) 21 November 1933 (1933-11-21) figures	1,2
A	US 2 559 418 A (FORD E. H.) 3 July 1951 (1951-07-03) figures	1-3
A	US 2 015 618 A (COOKE R. T.) 24 September 1935 (1935-09-24) cited in the application figures	1-3
A	US 1 200 070 A (BANBURY F. H.) 3 October 1916 (1916-10-03) cited in the application claims; figure	1,2

4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
GB 00/02057

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0170397 A	05-02-1986	AT 50938 T	15-03-1990
		DE 3576470 D	19-04-1990
		JP 2504401 B	05-06-1996
		JP 61028432 A	08-02-1986
US 4914635 A	03-04-1990	JP 2098463 C	02-10-1996
		JP 8002530 B	17-01-1996
		JP 63286303 A	24-11-1988
EP 0848988 A	24-06-1998	JP 11048239 A	23-02-1999
		AU 701559 B	28-01-1999
		AU 4840597 A	25-06-1998
		CN 1185371 A	24-06-1998
		US 5984516 A	16-11-1999
JP 08142046 A	04-06-1996	NONE	
US 1936248 A	21-11-1933	DE 541788 C	
		GB 376184 A	
US 2559418 A	03-07-1951	NONE	
US 2015618 A	24-09-1935	NONE	
US 1200070 A		NONE	

PATENT COOPERATION TREATY

REC'D 13 SEP 2001

WIPO PCT

PCT 10/031050

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

14

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
DE/J088404PWO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02057	26/05/2000	28/05/1999
International Patent Classification (IPC) or national classification and IPC B29B7/18		
Applicant CARTER BROS (ROCHDALE) LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21/12/2000	30.08.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Deubler, U Telephone No. +49 89 2399 2923

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/02057

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-8 as originally filed

Claims, No.:

1-17 as originally filed

Drawings, sheets:

1/2,2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☐ the entire international application.

   ☒ claims Nos. 17.

because:

   ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

   ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 17 are so unclear that no meaningful opinion could be formed (*specify*):
   see separate sheet

   ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

   ☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.

   ☐ the computer readable form has not been furnished or does not comply with the standard.

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   ☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☒ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☐ not complied with for the following reasons:

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☒ the parts relating to claims Nos. 1 - 15, 17.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; *citations and explanations supporting such statement*

1. Statement

Novelty (N)	Yes:	Claims 1 - 14
	No:	Claims 15
Inventive step (IS)	Yes:	Claims 1 - 14
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1 - 15
	No:	Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. *Certain observations on the international application*

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claim 17 does not contain any specific apparatus feature.
Therefore, it is not clear for what protection is sought (Article 6 PCT).

Re Item IV

Lack of unity of invention

Unity of invention has been objected and the Applicant has been invited to restrict the claims or to pay an additional fee.
As the Applicant failed to restrict or pay, according to Article 34(3)c) PCT claims 1 to 15 and 17 are regarded as the main invention on which examination is carried out.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

The following documents (D) are referred to in this report :

D1: EP-A-0 170 397 (SHAW PLC FRANCIS) 5 February 1986 (1986-02-05)
D2: US-A-4 914 635 (NISHIGAI KAZUHISA ET AL) 3 April 1990 (1990-04-03)
D3: EP-A-0 848 988 (KOBE STEEL LTD) 24 June 1998 (1998-06-24)
D4: PATENT ABSTRACTS OF JAPAN vol. 1996, no. 10, 31 October 1996 (1996-10-31) & JP 08 142046 A (BRIDGESTONE CORP), 4 June 1996 (1996-06-04)
D5: US-A-1 936 248 (LASCH A. ET AL) 21 November 1933 (1933-11-21)
D6: US-A-2 559 418 (FORD E. H.) 3 July 1951 (1951-07-03)

1.) The subject-matter of claims 1 to 14 meets the requirements of Articles 33(2) and (3) PCT (Novelty and Inventive Step), however the subject-matter of claim 15

does not meet the requirements of Articles 33(2) PCT, because the subject-matter of claim 15 is not new.

2.) The present invention relates to a mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having an axially extending projection and being rotatable so as to present a leading face of the projection to the material being mixed.
A mixing machine of this type is known from e.g. document D1.
The object of the invention is to avoid material to flow across the projections and to improve dispersion of the materials.
This object is achieved according to the invention by the leading face having a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.
None of the documents cited in the INTERNATIONAL SEARCH REPORT discloses or renders obvious the combination of these features in their entirety.
Therefore independent claim 1 meets the requirements of Articles 33 (2) and (3) PCT.

3.) The dependent claims 2 to 14 are related to further particular embodiments of the invention.
Therefore claims 2 to 14 meet the requirements of Articles 33 (2) and (3) PCT either.

4.) Document D1 (see in particular Fig. 2 and 4) discloses a mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases along the axial direction.
Thus all features of the subject-matter of independent claim 15 are known from document D1.
Consequently, the subject-matter of independent claim 15 is not new (Article 33(2) PCT).

Re Item VII

Certain defects in the international application

1.) It would have been appropriate to draft the independent claim(s) in the two-part form as required by Rule 6.3(b) PCT, whereby the features known from the closest prior art document (D1) should have been placed in the preamble.
The Applicant did not provide reasons why the claim should not be written in the two-part form. Neither did the Applicant clearly indicate in the description which features of the subject-matter of the independent claims are already known from the closest prior art document; see PCT Guidelines PCT/GL/3 III, 2.3a.

2.) The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
Only reference signs should be placed in parentheses !

3.) The documents D1 to D6 have not been identified in the description nor has the relevant background art disclosed therein been discussed. The requirements of Rule 5.1(a)(ii) PCT are, thus, not fulfilled.

4.) It should also be indicated in the description, which document represents the closest prior art.

5.) The object of the invention (single inventive concept) should have been specified more precisely in the description (not just "provide improved mixing machine") and this single object should completely be achieved by the invention as defined in the independent claim(s).

Re Item VIII

Certain observations on the international application

In claim 15 it is not clear what is meant by "along the axial direction" as an axis actually indicates two directions, i.e. the one direction and the reverse direction along the same axis (Article 6 PCT).

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 848 988 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.06.1998 Bulletin 1998/26

(51) Int. Cl.[6]: **B01F 7/08**, B29B 7/18

(21) Application number: **97121745.0**

(22) Date of filing: **10.12.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **02.06.1997 JP 142871/97**
24.04.1997 JP 106880/97
19.12.1996 JP 339901/96
16.07.1997 JP 190891/97

(71) Applicant:
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(72) Inventors:
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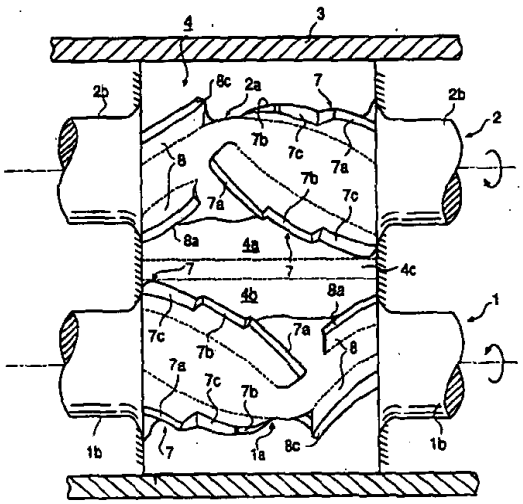
(54) Enclosed kneading apparatus

(57) An enclosed kneading apparatus which can smoothly knead and disperse kneaded products of various kneading conditions without the maintenance of a rotor moving mechanism for a first and second rotors and the operation which sacrifices the handling capacity of the kneading apparatus and at the same time, prevent an excessive increase in the temperature of the kneaded products. In the apparatus, the kneaded product of a desired kneading state is obtained by flowing a kneading object in tip clearances between the inner wall of a chamber and a first and second rotors while rotating the first and second rotors in the chamber, and by imparting a shearing force to disperse the kneading object. The respective first and second rotors are provided with three long wings in helical fashion each having a plurality of tip portions for providing a plurality of three tip clearances in the axial direction.

FIG. 1



EP 0 848 988 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an enclosed kneading apparatus for kneading materials such as rubber, plastic and so forth by rotating rotors in a chamber.

2. Description of the Related Art

Batch-type enclosed kneading apparatuses manufacture a batch of kneaded products by a series of operations such that kneading materials such as rubber, plastic and so forth are pressed into a chamber by a floating weight, the materials are kneaded by a pair of rotors provided in the chamber to obtain a kneaded product of a desired state, and the kneaded product is discharged from the chamber through a drop door.

The above kneading is performed by allowing a rotation force of the rotors to act as a shearing force on the kneaded product. It has been known that the shearing force is maximum in a clearance between the rotors and the inner wall of the chamber (hereinafter, referred to as tip clearance), and the maximum shearing force increases with the decrease of the tip clearance. Therefore, it is apparent that decreasing the tip clearance accelerates the kneading due to the dispersive action caused by a large shearing force. However, if the tip clearance decreases, a large shearing force is locally imparted to the kneaded product, so that the temperature of the kneaded product increases.

Thus, in the case of manufacturing a kneaded product having a low allowable temperature, steps are taken such that the tip clearance is set to increase, the rotor speed is decreased although productivity decreases, and the input amount of materials is reduced in order to prevent an increase in the temperature over the allowable temperature even if kneading efficiency is low. In addition, in the case of manufacturing a kneaded product having a high allowable temperature, the tip clearance is sufficiently decreased and the rotor speed is increased in order to obtain a large shearing force while attaching importance to kneading efficiency.

According to the above conventional arrangements, however, the tip clearance is suitable only for a specific kneading condition. Thus, unless the rotors are replaced so as to provide a tip clearance responsive to the kneading condition when the type of the kneaded product is switched to change the kneading condition, an excessive tip clearance or a too small tip clearance is provided which exacerbates the problems of insufficient kneading and dispersion, and the increase in temperature of the kneaded product over the allowable temperature. However, it is impractical to replace the rotors in response to the kneading condition. When the temperature of the kneaded product increases over the allowable temperature, the quality of the kneaded product is actually ensured at the sacrifice of the handling capacity of the kneading apparatus, i.e., by decreasing the speed of rotors and reducing the input amount of materials.

When merely increasing the cooling efficiency, an enclosed kneading apparatus as disclosed in Japanese Unexamined Patent Publication No. 63-47106 may be used in which two helical long wings extending in the axial direction are provided in the circumferential direction, scrapers are disposed at the back of the long wings, and a kneaded product layer attached to the inner surface of a chamber is scraped off by the scrapers, whereby the cooling efficiency through the chamber is increased. In the above enclosed kneading apparatus, however, only the long wings provide a specific tip clearance and perform a shearing function, and the technical idea of imparting the shearing function to the scrapers is not described, so that the apparatus is insufficient in the sense of a change of the tip clearance.

In addition, an enclosed kneading apparatus has been developed in which rotation axes of rotors can move so that the tip clearance can be arbitrarily changed in response to the kneading condition rather than impractical replacement of the rotors. In this case, however, checking and maintenance of a mechanism for moving the rotation axes of the rotors ate required each time the axes are moved, the setup time increases, and the checking operation becomes complicated.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an enclosed kneading apparatus which can smoothly knead and disperse kneaded products of various kneading conditions without requiring checking and maintenance operations and with no sacrifice in the inherent handling capacity of the kneading apparatus and at the same time, prevent an excessive increase in the temperature of the kneaded product.

In order to achieve the above object, in a first aspect of the present invention, there is provided an enclosed kneading apparatus comprising a chamber and a rotor provided with wings for providing a plurality of different tip clearances between the inner wall of the chamber and the rotor at least in the axial direction, so that a kneaded product of a desired kneading state is obtained by flowing a kneading object in the tip clearances while rotating the rotor in the chamber, and by imparting a shearing force to disperse the kneading object.

In a second aspect of the present invention, there is provided an enclosed kneading apparatus according to the first aspect, wherein the wings consist of long wings and short wings, and a plurality of different tip clearances are provided at least along the long wings.

In a third aspect of the present invention, there is provided an enclosed kneading apparatus according to

the second aspect, wherein at least two of the long wings and short wings are provided in the circumferential direction of said rotors, and a plurality of different tip clearances are provided at the at least two of the long wings and short wings.

In a fourth aspect of the present invention, there is provided an enclosed kneading apparatus according to the first aspect, wherein one of the plurality of tip clearances are provided by allowing the tops of the wings to be in close proximity to the inner wall of the chamber so as to scrape off the surface of the kneading object attached to the inner wall of the chamber and impart a strong shearing force to a part of the kneading object.

In a fifth aspect of the present invention, there is provided an enclosed kneading apparatus according to the first aspect, wherein the plurality of tip clearances include at least two tip clearances of a small tip clearance, a medium tip clearance, and a large tip clearance, and the ratio of the tip clearance to the inner diameter of the chamber is within the range of 0.0025 to 0.0250 at the small tip clearance, within the range of 0.0100 to 0.0500 at the medium tip clearance, and within the range of 0.0250 to 0.1000 at the large tip clearance.

In a sixth aspect of the present invention, there is provided an enclosed kneading apparatus according to the fifth aspect, wherein the ratio of the tip clearance to the inner diameter of the chamber is within the range of 0.00625 to 0.0125 at the small tip clearance, within the range of 0.0125 to 0.0250 at the medium tip clearance, and within the range of 0.0250 to 0.075 at the large tip clearance.

In a seventh aspect of the present invention, there is provided an enclosed kneading apparatus according to the first or the fourth aspect, wherein the wings include one wing having a plurality of stepwise tip clearances formed thereon.

In an eighth aspect of the present invention, there is provided an enclosed kneading apparatus according to the seventh aspect, wherein at least one tip clearance of the plurality of stepwise tip clearances is tapered.

In a ninth aspect of the present invention, there is provided an enclosed kneading apparatus according to the first or the fourth aspect, wherein the wings include one wing having a plurality of tapered tip clearances formed thereon.

In a tenth aspect of the present invention, there is provided an enclosed kneading apparatus according to the first or the fourth aspect, wherein the wings of the rotors are constituted by divided segments.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view of rotors in an enclosed kneading apparatus according to the present invention;

Fig. 2 is a development of the rotor;

Fig. 3 is an illustration showing a state in which a kneading object is kneaded;

Figs. 4A and 4B are illustrations each showing a flowing state of the kneading object, in which Fig. 4A shows the flow state in the enclosed kneading apparatus according to the present invention, and Fig. 4B shows the flow state in a conventional enclosed kneading apparatus;

Figs. 5A and 5B are illustrations each showing states of long wings and short wings of a rotor, in which Fig. 5A is a development of the rotor, and Fig. 5B is an axial cross-sectional view of the rotor;

Fig. 6 is a development of the rotor;

Fig. 7 is a development of the rotor;

Fig. 8 is a development of the rotor;

Fig.9 is a development of the rotor;

Fig. 10 is a development of the rotor;

Figs. 11A to 11E are views each showing the appearance of a plurality of tip clearances of one wing;

Fig. 12 is a development of the rotor used in experiments;

Fig. 13 is a graph showing properties of the rotors of the present invention and the comparative example when the rotor speed is 60 rpm;

Fig. 14 is a graph showing properties of the rotors of the present invention and the comparative example when the rotor speed is 90 rpm; and

Fig. 15 is a perspective view of a rotor of a divided segment type.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention will now be described with reference to Figs. 1 to 10.

An enclosed kneading apparatus according to the present invention includes a pair of first rotor 1 and second rotor 2, and a case 3 for rotatably supporting these rotors 1 and 2. A cooling pipe (not shown) is connected to the outer wall of the case 3 so as to cool a kneaded product. A chamber 4 for accommodating the kneaded product is formed inside the case 3. The chamber 4 is formed to have a vertical cross section having the shape of two overlapping circles, as shown in Fig. 3, and consists of a pair of first kneading chamber 4a and second kneading chamber 4b each having an inner diameter D, and a communication section 4c for communicating between these kneading chambers 4a and 4b.

A floating weight 5 for pressing kneading materials such as rubber, plastic and so forth into the chamber 4 is provided at the upper center of the case 3 so as to move up and down. On the other hand, a drop door 6 for discharging a kneaded product is provided at the lower center of the chamber 4. The arrangement is such that the floating weight 5 and the drop door 6 are closely brought into contact with the case 3 during kneading to form a part of the inner wall of the chamber 4.

The first and the second rotor 1 and 2 are inserted through the first and the second kneading chambers 4a and 4b, respectively, as shown in Fig. 1. These rotors 1 and 2 are disposed so that their axes are parallel to

each other, and they are rotated by a drive mechanism (not shown) in directions opposite to each other. In addition, these rotors 1 and 2 are formed into the same shape having long wings 7 and short wings 8, as will be described later.

The respective rotors 1 and 2 are formed at both rotor kneading portions 1a and 2a accommodated in the chamber 4, and have rotor support portions 1b, 1b and 2b, 2b which are rotatably supported by the case 3. The respective rotor kneading portions 1a and 2a have three long wings 7 and short wings 8 which are circumferentially equally disposed by 120E and axially extending, as also shown in Fig. 2. The respective long wings 7 are feed wings formed in helical fashion from one wall surface of the chamber toward the middle of the other wall surface. On the other hand, the respective short wings 8 are return wings formed in reverse helical fashion from between the end of the long wings 7 to the other wall surface of the chamber 4 so as to be located on the other side of the long wings 7.

A tip of each of the long wings 7 is divided into a high tip portion 7a, a medium tip portion 7b and a low tip portion 7c, and three tip portions having different heights appear in the axial direction. Further, the three tip portions having different heights also appear alternately in the circumferential direction of the long wings 7. The respective tip portions 7a, 7b and 7c are set to increase a tip clearance (clearance between the tip portion and the inner wall of the chamber 4) in the order of a small tip clearance, a medium tip clearance, and a large tip clearance.

That is, the arrangement is such that the high tip portions 7a are in close proximity to the inner wall of the chamber 4 so as to provide the smallest tip clearance so that, when the rotors 1 and 2 rotate, the high tip portions 7a impart a large shearing force to the kneaded product to increase kneading efficiency and dispersing efficiency, and scrape the surface of the kneaded product attached to the inner wall of the chamber 4 to increase cooling efficiency. Further, the high tip portions 7a allows most of the advancing kneaded product to flow in the axial direction to accelerate axial flowing of the kneaded product and at the same time, to accelerate flowing of the kneaded product between the first kneading chamber 4a and the second kneading chamber 4b.

On the other hand, the low tip portions 7c are sufficiently separated from the inner wall of the chamber 4 so as to provide the largest tip clearance. When the rotors 1 and 2 rotate, the low tip portions 7c increase the amount of the kneaded product passing through the tip clearance to accelerate flowing of the kneaded product in the kneading chambers 4a and 4b and at the same time, prevent a large shearing force from being imparted locally to the kneaded product to suppress an excessive increase in the temperature of the kneaded product.

The medium tip portions 7b are set to provide an intermediate tip clearance between the tip clearances of the high tip portions 7a and the low tip portions 7c so as to adjust the shearing force and flowing of the kneaded products of the high tip portions 7a and the low tip portions 7c.

The tip clearances may be set in any one of the following orders: medium, small, and large tip clearance; large, medium, and small tip clearance; and small, large, and medium tip clearance.

The respective short wings 8 provided on the other side of the long wings 7 are formed to have a high tip 8a, a medium tip 8b, and a low tip 8c, as shown in Fig. 2. The high tips 8a of the short wings 8 are in close proximity to the inner wall surface of the chamber 4 so as to provide the smallest tip clearance, similarly to the high tip portions 7a of the long wings 7 so that the high tips 8a impart a large shearing force to the kneaded product, scrape the surface of the kneaded product attached to the inner wall surface of the chamber 4, and accelerate flowing of the kneaded produce in the axial direction and between the kneading chambers 4a and 4b.

The low tips 8c are sufficiently separated from the inner wall of the chamber 4 so as to provide the largest tip clearance, similarly to the low tip portions 7c of the long wings 7 so that the low tips 4c increase the amount of the kneaded product passing through tip clearance, accelerate flowing of the kneaded product in the kneading chambers 4a and 4b, and prevent a large shearing force from being imparted locally to the kneaded product.

The medium tips 8b are set to provide an intermediate tip clearance between the tip clearances of the high tips 8a and the low tips 8c, similarly to the medium tip portions 7b of the long wings 7, so as to adjust the shearing force and flowing of the kneaded products of the high tips 8a and the low tips 8c.

A description will be given of the operation of the enclosed kneading apparatus of the present invention having the described construction.

First, as shown in Fig. 3, the floating weight 5 is separated from the case 3 with the drop door 6 closely in contact with the case 3 to thereby open the top surface of the chamber 4. After charging kneading materials such as rubber, plastic, filling materials, and so forth into the chamber 4 from the opening, the floating weight 5 is brought into close contact with the case 2 and pressed into the communication section 4c of the chamber 4. In addition, almost simultaneously, cooling water or the like is flown into the cooling pipe connected to the outer wall of the case 3 so as to cool the kneading materials in the chamber 4 through the case 3. Depending on the configuration and type of the kneading materials, a heating medium such as hot water, vapor and so forth may be flown in the cooling pipe in order to heat the kneading materials.

Next, in order to obtain a kneaded product of a desired kneading state while shearing and dispersing the kneading materials, the first and second rotors 1 and 2 are rotated in the opposite directions to start kneading. Since the high tip portions 7a of the long

wings 7 and the high tips 8a of the short wings 8 are set to provide a small clearance, if pieces of block-like rubber are charged as kneading materials into the communication section 4c, these materials are moved to the first and second kneading chambers 4a and 4b by a large shearing force, as shown in Fig. 3 when the first and second rotors 1 and 2 are rotated. Therefore, the kneading materials can be always dispersed into all the spaces in the chamber 4 in a short time after the start of kneading even if the kneading materials have a wide variety of shapes and sizes.

When the kneading materials are kneaded while being dispersed in the chamber 4 as described above, the respective tip portions 7a, 7b, and 7c of the long wings 7, and the respective tips 8a, 8b, and 8c of the short wings 8 act on a kneading object consisting of kneading materials and kneaded products as follows.

Figs. 4A and 4B are illustrations showing the flow states of the kneading object in the enclosed kneading apparatus of the present invention and in the conventional enclosed kneading apparatus, respectively. In the drawings, the hatching portions show fill quantities of the kneading object, vectors show flow rates and directions of the kneading object, and open arrows show flow directions and flow rates of the kneading object in the communication section 4c.

Referring to Fig. 4A, since the small tip clearance is provided at the high tip portions 7a of the long wings 7 and the high tips 8a of the short wings 8 as described above, a small amount of the kneading object passes through the tip clearance. Therefore, the kneading object of the advance side of the high tip portions 7a and the high tips 8a flows in the axial direction in large amounts, whereby most of the kneading object moves to the advance side of the axially adjacent medium tip portions 7b of the long wings 7 and to the medium tips 8b of the short wings 8, and a part of the kneading object passes through the tip clearance. A large shearing force due to the small tip clearance is imparted to the part of the kneading object to disperse it. In addition to the dispersion, the temperature of the sheared kneading object suddenly increases However, since most of the kneading object flows in the axial direction, the increase in the temperature of the overall kneading object is suppressed. Therefore, the kneading object can be continuously dispersed by a large shearing force even if the allowable temperature of the kneading object is low.

In addition, the high tip portions 7a of the long wings 7 and the high tips 8a of the short wings 8 move at the position in close proximity to the inner wall of the chamber 4, so that they scrape off the surface of the kneading object attached to the inner wall of the chamber 4. Therefore, the thickness of the kneading object attached to the inner wall of the chamber 4 becomes thin, and cooling efficiency by the cooling pipe through the chamber 4 is improved, so that the increase in the temperature of the kneading object can be further suppressed. Further, when the high tip portions 7a of the long wings 7 and the high tips 8a of the short wings 8 move in the communication section 4c, the kneading object is pressed from one of the first and second kneading chambers 4a and 4b to the other one of the first and second kneading chambers 4b and 4a by a large pressing force, so that flowing of the kneading object between the first and second kneading chambers is accelerated.

The large tip clearance is provided at the low tip portions 7c of the long wings 7 and the low tips 8c of the short wings 8, so that a large amount of the kneading object passes through the tip clearance. Therefore, the kneading object of the advance side of the low tip portions 7c and the low tips 8c flows in the circumferential direction in large amounts, whereby most of the kneading object moves to the advance side of the circumferentially adjacent medium tip portions 7b of the long wings 7 and the medium tips 8b of the short wings 8, and a part of the kneading object flows in the axial direction. In addition, the pressing force for pressing out the kneading object is small, so that flowing of the kneading object to the other first and second kneading chambers 4a and 4b when the low tip portions 7c and the low tips 8c move in the communication section 4c is suppressed. Therefore, flowing of the kneading object in the same pair of the kneading chambers 4a and 4b is accelerated and at the same time, and the large tip clearance reduces the shearing force to the kneading object, so that an excessive increase in the temperature of the kneading object is suppressed.

The medium tip portions 7b of the long wings 7 and the medium tips 8b of the short wings 8 are set to provide an intermediate tip clearance between the tip clearances of the high tip portions 7a and the low tip portions 7c, so that the shearing force and flowing of the kneading object are adjusted.

When the kneading object is kneaded as described above, first kneading spaces 10a for allowing the kneading object to flow in large amounts in the circumferential direction, second kneading spaces 10b for dispersing a small amount of the kneading object by a large shearing force while allowing a large amount of the kneading object to flow in the axial direction, and third kneading spaces 10c for allowing the kneading object to flow in the axial and circumferential directions by imparting an intermediate shearing force are provided continuously in the circumference and axial directions. Therefore, as compared with the conventional enclosed kneading apparatus shown in Fig. 4B in which long wings 7 and short wings 8 have medium tip portions 7b and medium tips 8b, respectively, the kneading object is uniformly dispersed in the first to third kneading spaces 10a to 10c while flowing actively. Thus, the kneaded product of a good kneading state can always be obtained without changing the tip clearance in response to kneading conditions of the kneading object, or without any sacrifice in the inherent handling capacity

of the kneading apparatus, i.e. without changing the rotor speed, the input amount of materials and so forth.

As described above, the enclosed kneading apparatus of this embodiment obtains the kneaded product of a desired kneading state by flowing the kneading object in tip clearances between the inner wall of the chamber 4 and the first and second rotors 1 and 2 while rotating the first and second rotors 1 and 2 in the chamber 4, and by imparting a shearing force to disperse the kneading object, as shown in Fig. 1. The respective first and second rotors 1 and 2 are provided with wings having the long wings 7 and the short wings 8 which are equally spaced at three positions in the circumferential direction so as to provide a plurality of three different tip clearances in the axial and circumferential directions.

According to the described arrangements, in the smallest tip clearance of the three tip clearances provided by the long wings 7 and the short wings 8, most of the kneading object of the advance side of the tip clearance is flown in the axial direction, and a part of the kneading object is passed through the clearance and is subjected to dispersion by a large shearing force. On the other hand, in the large tip clearance, most of the kneading object of the advance side is passed therethrough to accelerate circumferential flow, and an increase in the temperature is prevented by a small shearing force. When large and small different tip clearances appear in the circumference and axial directions, the kneading object is dispersed by a large shearing force while actively flowing in the entire chamber 4, and an increase in the temperature of the kneading object during dispersion is prevented. Therefore, the kneading object of various kneading conditions can always be made into a kneaded product of a desired state without the maintenance of the rotor moving mechanism and the operation which sacrifices the handling capacity of the apparatus performed in the conventional kneading apparatus.

The number of rollers may be one, or three or more. In addition, in this embodiment, three different tip clearances are provided by the high to low tip portions 7a to 7c of the long wings 7 and the high to low tips 8a to 8c of the short wings 8 which are spaced equally at three positions in the circumferential direction. However, the provision of the short wings 8, the arrangement, the number and the helical angle of the long wings 7 and the short wings 8, and the axial length of the wing on which each of the tip clearances is provided may be arbitrarily selected so long as two or more steps of different tip clearances are provided at least in the axial direction.

More specifically, the rotors may be provided with only the long wings 7, or the long wings 7 and the short wings 8 may be equally spaced at two positions in the circumferential direction, as shown in Figs. 5A and 5B. In addition, the ends of the long wings 7 may agree with those of the short wings 8, as shown in Figs. 6 and 7, and the high tip portions 7a to the low tip portions 7c providing three-stage tip clearances may be formed on the long wings in four divided sections, as shown in Fig. 8. Further, as shown in Fig. 9, the long wing 7 having the high tip portion 7a alone, the long wing 7 having the medium tip portion 7b alone, and the long wing 7 having the low tip portion 7c alone may be spaced equally in the circumferential direction so that the tip clearances equal to each other in the axial direction are provided in three stages in the circumferential direction. The number of sections of the tip clearances at the long wings 7 and the short wings 8 may be preferably up to ten so that the wings may be easily manufactured.

Still further, as shown in Fig. 10, the long wings 7 and the short wings 8 may be formed with a large helical angle. The helical angle may be preferably set within the range of 10E to 60E. This is because the small helical angle decreases the axial flowing of the kneading object and the amount of the kneading object passing through the tip clearance increases, thereby accelerating the dispersing operation, while the large helical angle increases the axial flowing of the kneading object, thereby accelerating mixing in the chamber 4, and the helical angle within the range of 10E to 60E can bring out simultaneously the above two characteristics.

The plurality of tip clearances are not limited to one in which a large, a medium, and a small tip clearance are provided stepwise in straight lines. For example, when the long wings 7 are viewed from the direction perpendicular to the wing face in the development of the rotor of Fig. 2, the long wings 7 have three patterns of a first long wing, a second long wing, and a third long wing, as shown in Fig. 11A. The first wing provides a plurality of tip clearances with respect to one wing in the order of large, medium, and small tip clearances. The second wing provides a plurality of tip clearances with respect to one wing in the order of small, large, and medium tip clearances. The third wing provides a plurality of tip clearances in the order of medium, small, and large tip clearances.

Tapered tip clearances may also be formed, as shown in Figs. 11B to 11E. The tip clearances of Fig. 11B are provided by the first long wing which is entirely linearly tapered. The second and third long wing provide combinations of the same tapers and stepped portions. In Fig. 11C, the large tip clearance remains straight, and the rest of medium and small tip clearances are tapered. In Fig. 11C, the medium or the small tip clearance may remain straight, and the rest of tip clearances may be tapered. In Fig. 11D, tapered tip clearances are combined so that bend points are provided rather than the stepped portions. In Fig. 11E, the large, medium, and small tip clearances are divided by slight steps and tapered portions. These tapered tip clearances may be adapted to all of the wings, a specific wing among all of the wings, or a part of the plurality of tip clearances of a specific wing. In addition, the tip clearances may be tapered in smooth curves.

The bend point and the corner of the stepped por-

tions may preferably be chamfered, or provided with a radius from the viewpoint of preventing breakage and chipping.

The rotors can be manufactured by monobloc casting or skiving. However, a so-called divided-segment system can be adopted in which the overall wings or the long wings are divided into a plurality of segments. In this case, by shifting phases of the divided segments, as shown in Fig. 15, the flow of the kneading object is changed greatly, whereby the degree of kneading of the kneading object is further improved.

The widths of the respective divided segments may be formed equally or unequally, and the twist angle of the wing may be fixed or changed. They may be freely designed without departing from the technical idea of the present invention.

Experimental Examples

The results of a kneading test obtained by an experimental small enclosed kneading apparatus will now be described. A kneading chamber having a capacity of 4 liters was used. The arrangement of the wings of the rotors, and the arrangement of the large, medium, and small tip clearances used in the present invention are shown in the development of Fig. 12. The large tip clearance L was 6 mm (the ratio of the large clearance L to the inner diameter of 128.6 mm of the chamber was 0.0467), the medium tip clearance M was 3 mm (the ratio of the medium clearance M to the inner diameter of 128.6 mm of the chamber was 0.0233), and the small tip clearance S was 1 mm (the ratio of the small clearance S to the inner diameter of 128.6 mm of the chamber was 0.0078). The arrangement of the wings used in a comparative example was the same as that of the present invention, but all the tip clearances were 3 mm.

In both of the present invention and the comparative example, a compound containing 100 parts of natural rubber (CV60) and 50 parts of carbon black (SAF) was subjected to the kneading test. In addition, the rate of the compound charged in the kneading chamber was 70 %, the ram pressure was 5 kgf /cm^2, and the temperature of cooling water flown into the case and rotors was 30 EC in both of the present invention and the comparative example.

The changes with time of the temperature Tdis (EC) of the kneaded product, the mechanical energy Esp (KWh/kg) imparted to the kneaded product, and Mooney viscosity of the kneaded product were measured. Their changes with time when the rotor speed is 60 rpm is shown in Fig. 13, and those when the rotor speed is 90 rpm is shown in Fig. 14. In these drawings, Y represents the rotors of the present invention, and X represents the rotors of the comparative example.

According to Figs. 13 and 14, the following differences in properties between the rotors Y of the present invention and the rotors X of the comparative example exist.

1) The mechanical energy imparted to the kneaded product of the rotors Y of the present invention is larger than that of the rotors X of the comparative example.

2) The temperature of the kneaded product of the rotors Y of the present invention is slightly higher than that of the rotors X of the comparative example, but they are substantially equal.

3) The Mooney viscosity of the kneaded product of the rotors Y of the present invention is lower than that of the rotors X of the comparative example. In addition, as shown in Fig. 14, the rotors X of the comparative example decreases the Mooney viscosity to a lesser extent with the passage of time, while the rotors Y of the present invention decreases the Mooney viscosity substantially in proportion to the passage of time.

The above differences in properties 1) to 3) show that the rotors Y of the present invention have cooling capability higher than that of the rotors X of the comparative example, and can impart much mechanical energy to the kneaded product. In addition, it is shown that the higher the mechanical energy imparted, the more the viscosity of the kneaded product tends to decrease, and the rotors Y of the present invention can provide a kneaded product excellent in processability as compared with the rotors X of the comparative example.

In one form of the invention, there is provided an enclosed kneading apparatus for obtaining a kneaded product of a desired kneading state by flowing a kneading object in a tip clearance between the inner wall of a chamber and rotors while rotating the rotors in the chamber, and by imparting a shearing force to disperse the kneading object, wherein the rotors are provided with wings for providing a plurality of different tip clearances at least in the axial direction. In an another form of the invention, there is provided an enclosed kneading apparatus, wherein the wings consist of long wings and short wings, and a plurality of different tip clearances are provided at least along the long wings. In a still another form of the invention, there is provided an enclosed kneading apparatus, wherein at least two of the long wings and short wings are provided in the circumferential direction of said rotors, and a plurality of different tip clearances are provided at the at least two of the long wings and short wings.

These features of the invention offer the following advantages. The different tip clearances provided by the wings can be relatively divided into a small tip clearance and a large tip clearance. In the small tip clearance, most of the kneading object of the advance side of the tip clearance is flown in the axial direction, and a part of the kneading object is passed through the clearance and is subjected to dispersion by a large shearing force. On the other hand, in the large tip clearance, most of the kneading object of the advance side is passed therethrough to accelerate circumferential flow, and an

increase in the temperature is prevented by a small shearing force. Thus, when large and small different tip clearances appear at least in the axial direction, the kneading object is dispersed by a large shearing force while actively flowing in the entire chamber, and an increase in the temperature of the kneading object during dispersion is prevented. Therefore, various kneading objects can always be made into kneaded products of desired states without the maintenance of the rotor moving mechanism and the operation which sacrifices the handling capacity of the apparatus performed in the conventional kneading apparatus.

In a further form of the invention, there is provided an enclosed kneading apparatus, wherein one of the plurality of tip clearances are provided by allowing the tops of the wings to be in close proximity to the inner wall of the chamber so as to scrape off the surface of the kneading object attached to the inner wall of the chamber and impart a strong shearing force to a part of the kneading object. This feature of the invention offers the following advantages. The wings in close proximity to the inner wall of the chamber periodically scrape off most of the kneading object attached to the inner wall of the chamber with the rotation of the rotors, so that the thickness of the kneading object attached becomes thin, whereby cooling efficiency for cooling the kneading object through the chamber is improved.

In a still further form of the invention, there is provided an enclosed kneading apparatus, wherein the plurality of tip clearances include at least two tip clearances of a small tip clearance, a medium tip clearance, and a large tip clearance, and the ratio of the tip clearance to the inner diameter of the chamber is within the range of 0.0025 to 0.0250 at the small tip clearance, within the range of 0.0100 to 0.0500 at the medium tip clearance, and within the range of 0.0250 to 0.1000 at the large tip clearance. This feature of the invention offers the following advantages. The ratio of the small tip clearance to the inner diameter of the chamber is within a predetermined range, and functions of fracturing a filler and an aggregate or a gel of additives contained in a kneaded product, and dispersing them into the kneaded product can be performed. In addition, the ratios of the medium tip clearance and the large tip clearance to the inner diameter of the chamber are within predetermined ranges, respectively, and a uniform shearing operation can be imparted to the kneaded product.

In an another form of the invention, there is provided an enclosed kneading apparatus, wherein the ratio of the tip clearance to the inner diameter of the chamber is within the range of 0.00625 to 0.0125 at the small tip clearance, within the range of 0.0125 to 0.0250 at the medium tip clearance, and within the range of 0.0250 to 0.075 at the large tip clearance. This feature of the invention offers the following advantage. Both of the dispersion of the aggregate or the gel into the kneaded product and the imparting of the uniform shearing operation to the kneaded product can be achieved in good balance.

In a further form of the invention, there is provided an enclosed kneading apparatus, wherein at least one tip clearance of the plurality of stepwise tip clearances is tapered. In a still further form of the invention, there is provided an enclosed kneading apparatus, wherein the wings include one wing having a plurality of tapered tip clearances formed thereon. These features of the invention offer the following advantages. The tapered tip clearances can change the flow of the kneaded product, and a easy-to-work shape of the rotor can be adopted.

In a still another aspect of the invention, there is provided an enclosed kneading apparatus, wherein the wings of the rotors are constituted by divided segments. This feature of the invention offers the following advantage. The wings can be easily worked, whereby a degree of freedom of design of the wings is increased.

An enclosed kneading apparatus which can smoothly knead and disperse kneaded products of various kneading conditions without the maintenance of a rotor moving mechanism for a first and second rotors and the operation which sacrifices the handling capacity of the kneading apparatus and at the same time, prevent an excessive increase in the temperature of the kneaded products. In the apparatus, the kneaded product of a desired kneading state is obtained by flowing a kneading object in tip clearances between the inner wall of a chamber and a first and second rotors while rotating the first and second rotors in the chamber, and by imparting a shearing force to disperse the kneading object. The respective first and second rotors are provided with three long wings in helical fashion each having a plurality of tip portions for providing a plurality of three tip clearances in the axial direction.

Claims

1. An enclosed kneading apparatus comprising:

   a chamber; and
   a rotor, said rotor being provided with wings for providing a plurality of different tip clearances between the inner wall of said chamber and said rotor at least in the axial direction.

2. An enclosed kneading apparatus according to claim 1, wherein said wings consist of long wings and short wings, and a plurality of different tip clearances are provided at least along said long wings.

3. An enclosed kneading apparatus according to claim 2, wherein at least two of said long wings and short wings are provided in the circumferential direction of said rotors, and a plurality of different tip clearances are provided at said at least two of said long wings and short wings.

4. An enclosed kneading apparatus according to

claim 1, wherein one of said plurality of tip clearances are provided by allowing the tops of said wings to be in close proximity to the inner wall of said chamber so as to scrape off the surface of the kneading object attached to the inner wall of said chamber and impart a strong shearing force to a part of the kneading object.

5. An enclosed kneading apparatus according to claim 1, wherein said plurality of tip clearances include at least two tip clearances of a small tip clearance, a medium tip clearance, and a large tip clearance, and the ratio of the tip clearance to the inner diameter of said chamber is within the range of 0.0025 to 0.0250 at the small tip clearance, within the range of 0.0100 to 0.0500 at the medium tip clearance, and within the range of 0.0250 to 0.1000 at the large tip clearance.

6. An enclosed kneading apparatus according to claim 5, wherein the ratio of the tip clearance to the inner diameter of said chamber is within the range of 0.00625 to 0.0125 at the small tip clearance, within the range of 0.0125 to 0.0250 at the medium tip clearance, and within the range of 0.0250 to 0.075 at the large tip clearance.

7. An enclosed kneading apparatus according to claim 1 or 4, wherein said wings include one wing having a plurality of stepwise tip clearances formed thereon.

8. An enclosed kneading apparatus according to claim 7, wherein at least one tip clearance of said plurality of stepwise tip clearances is tapered.

9. An enclosed kneading apparatus according to claim 1 or 4, wherein said wings include one wing having a plurality of tapered tip clearances formed thereon.

10. An enclosed kneading apparatus according to claim 1 or 4, wherein the wings of said rotors are constituted by divided segments.

FIG. 1

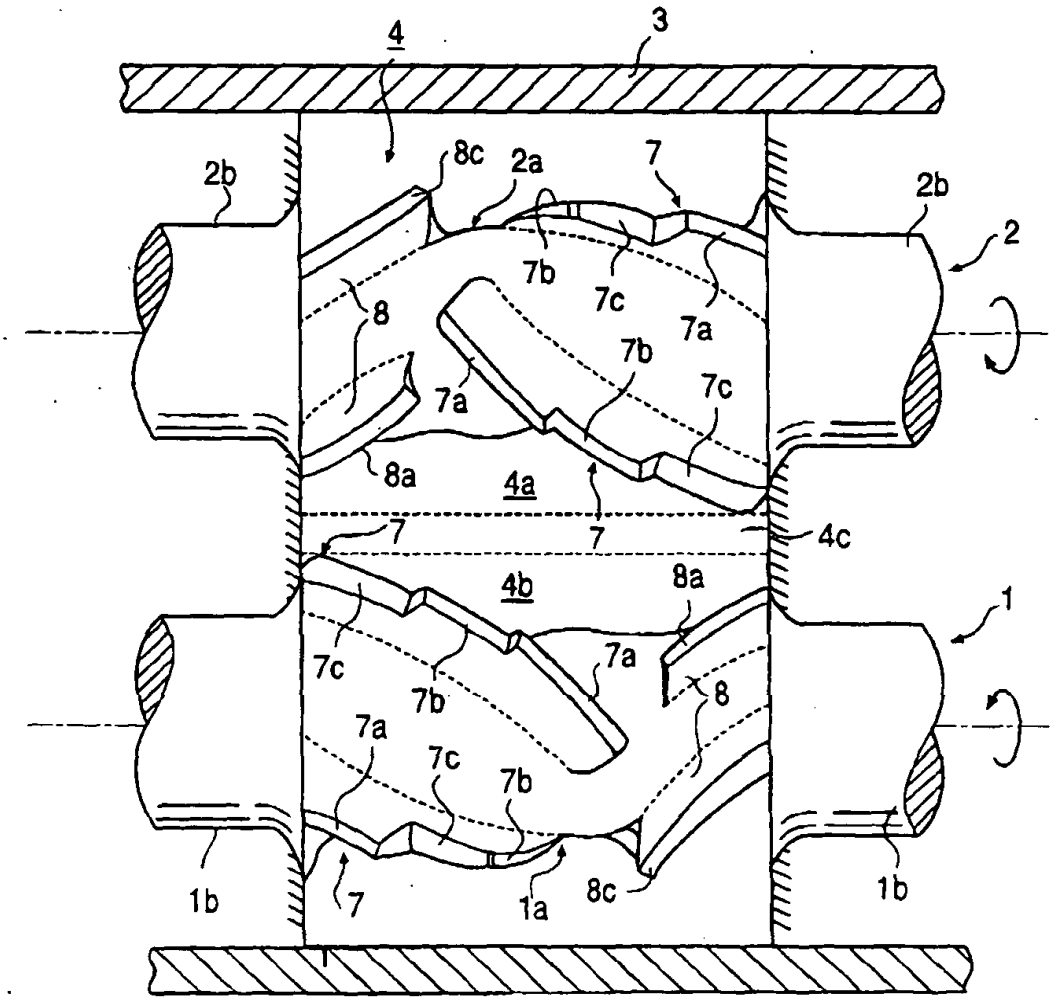


FIG. 2

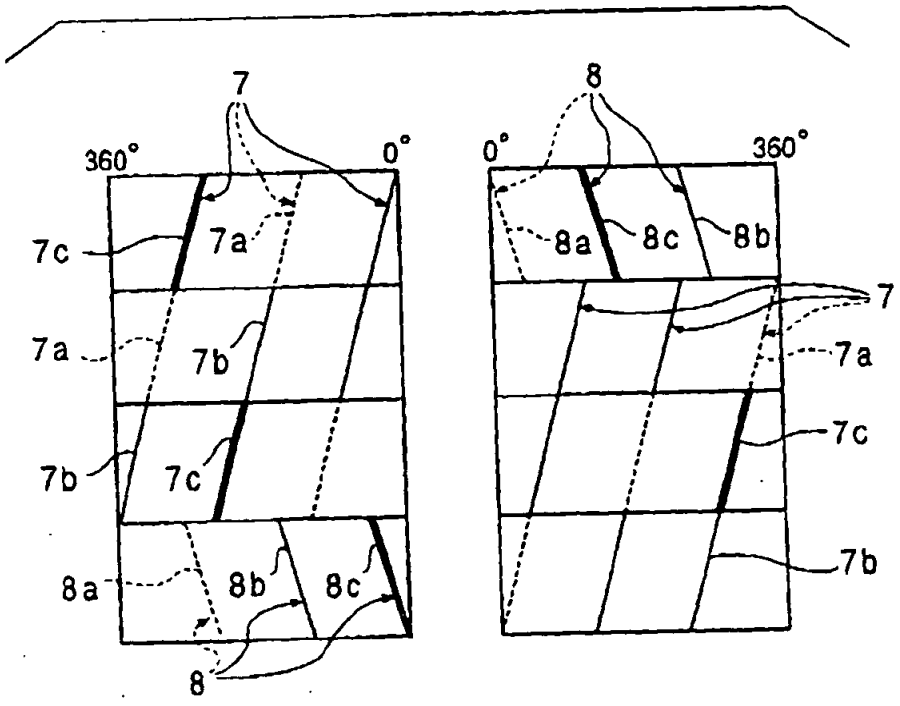


FIG. 3

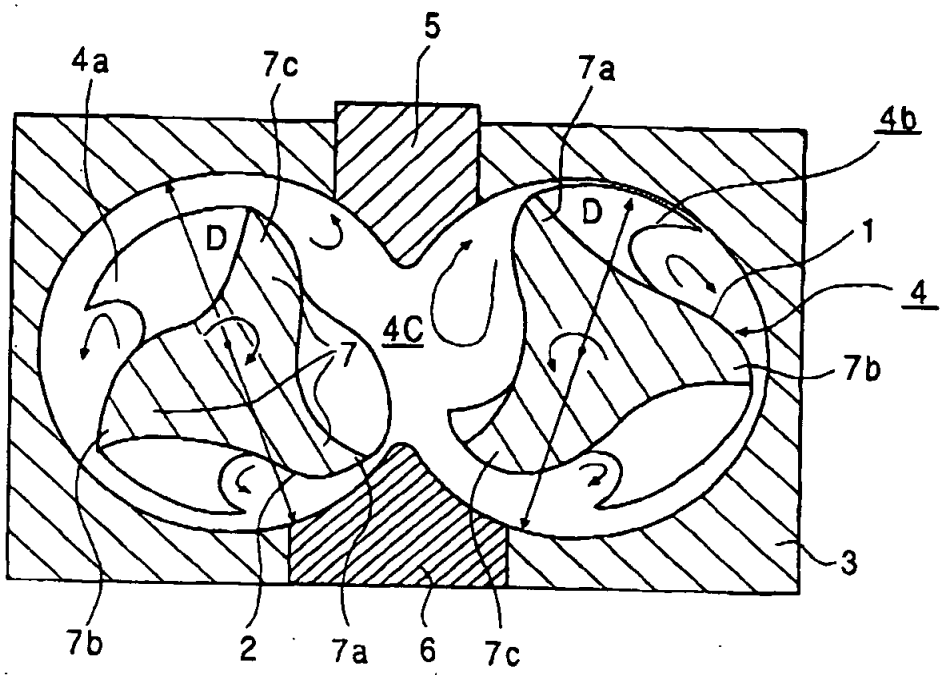


FIG. 4A

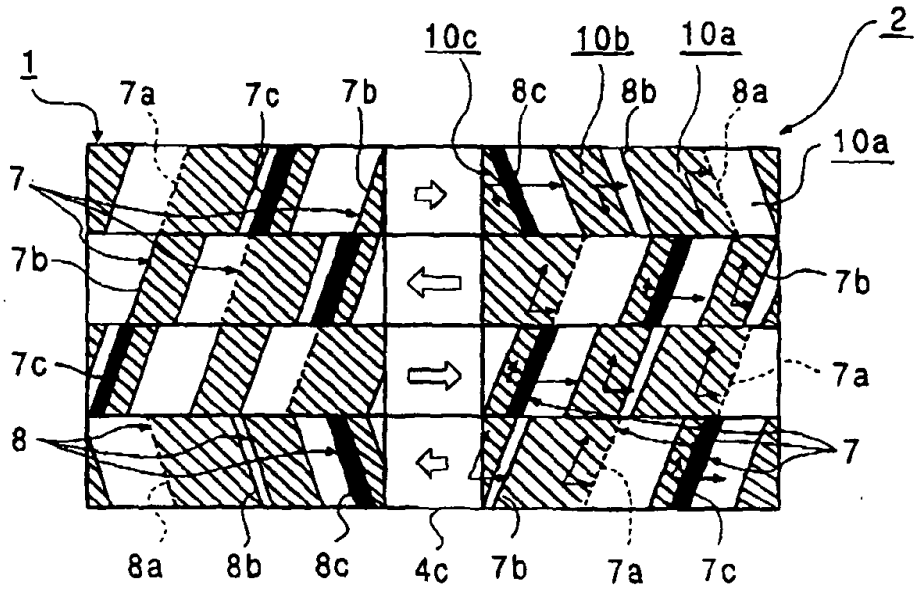

1
2
10c
10b
10a
7a
7c
7b
8c
8b
8a
10a
7
7b
7b
7c
7a
8
7
8a
8b
8c
4c
7b
7a
7c

FIG. 4B

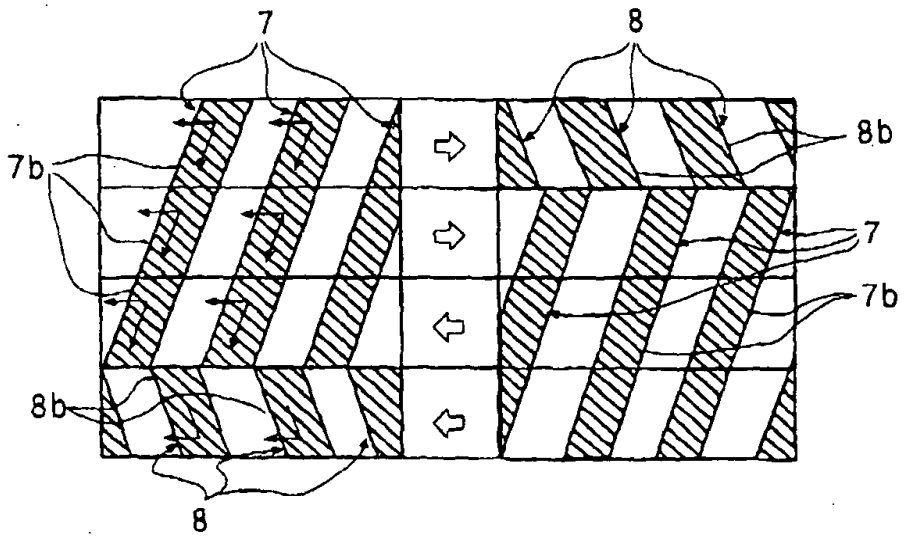

7
8
8b
7b
7
7b
8b
8

FIG. 5A

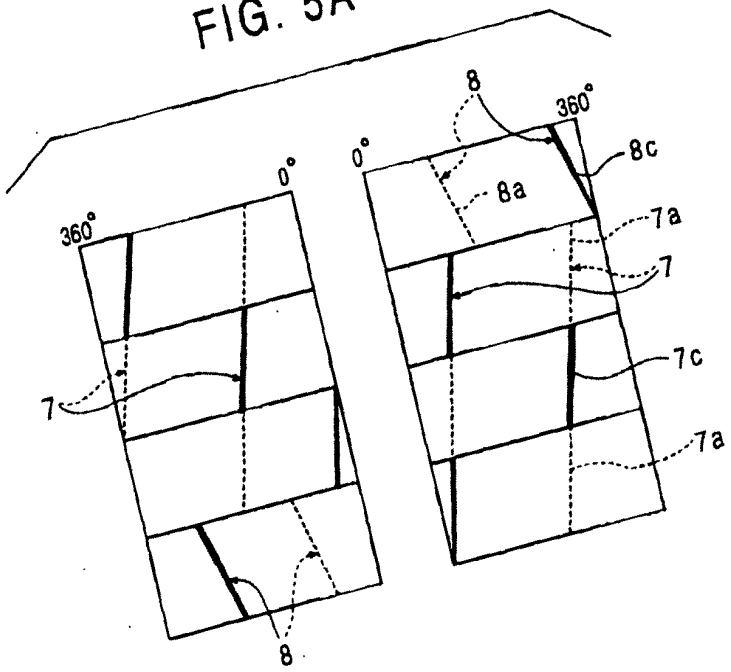


FIG. 5B

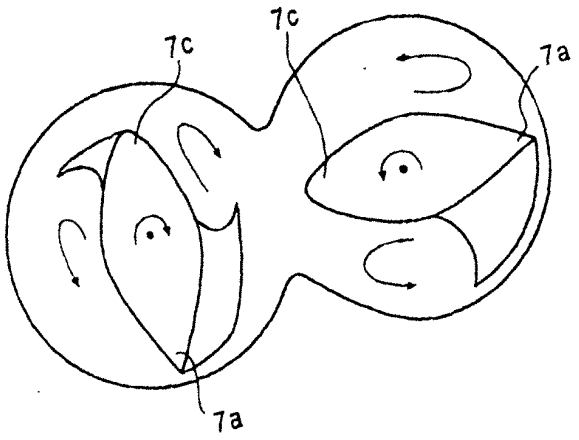


FIG. 6

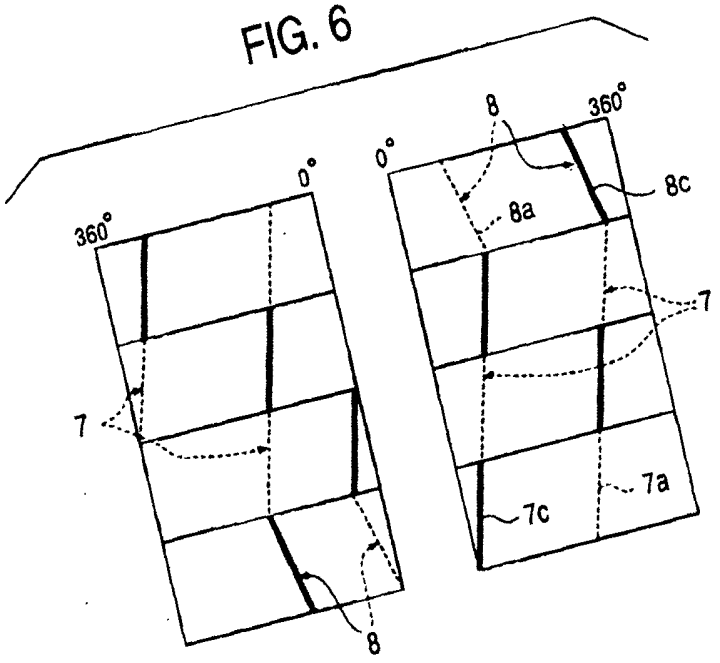


FIG. 7

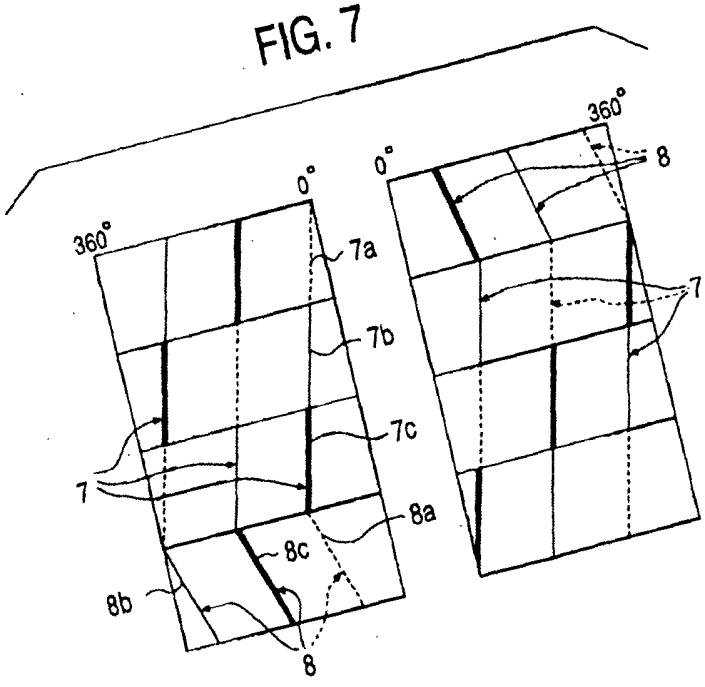


FIG. 8

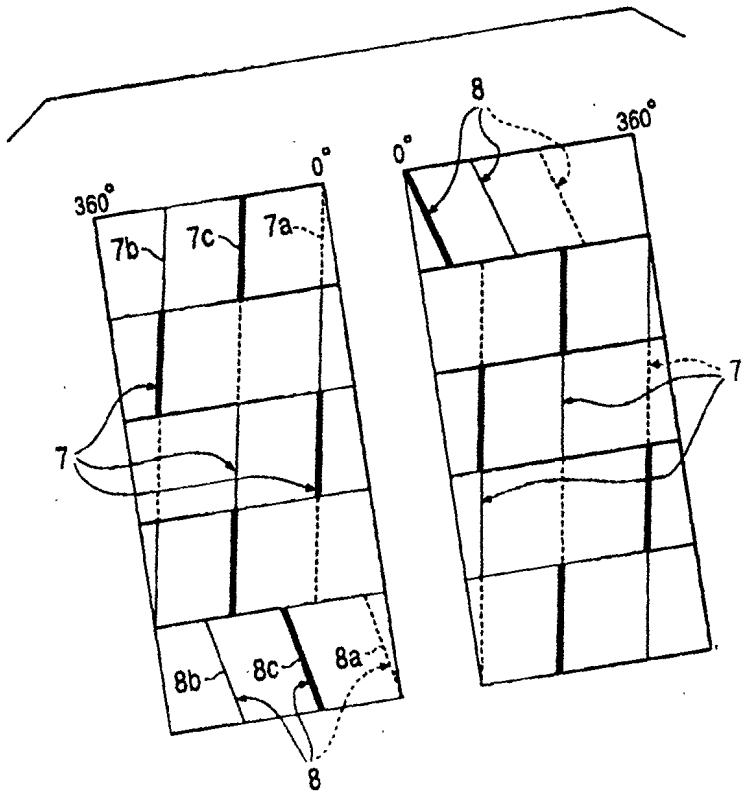


FIG. 9

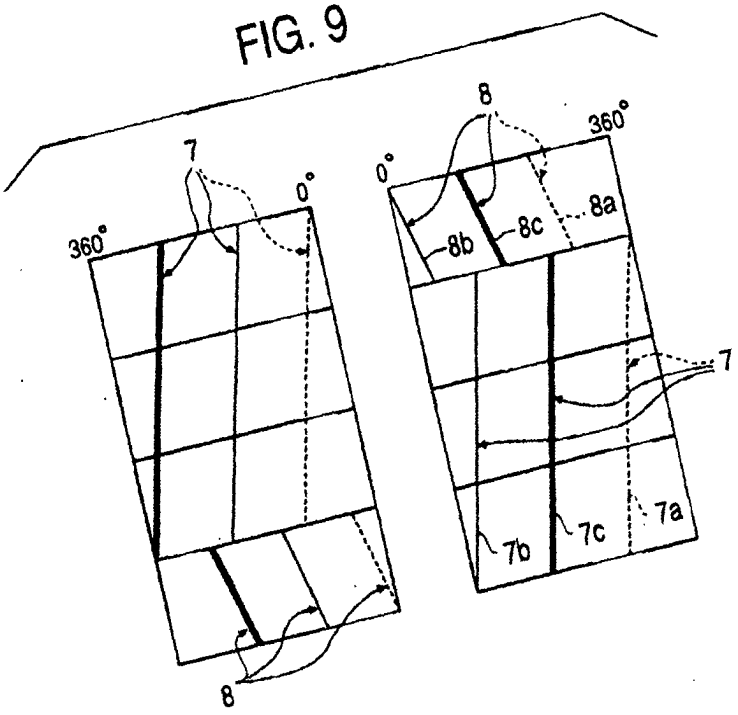
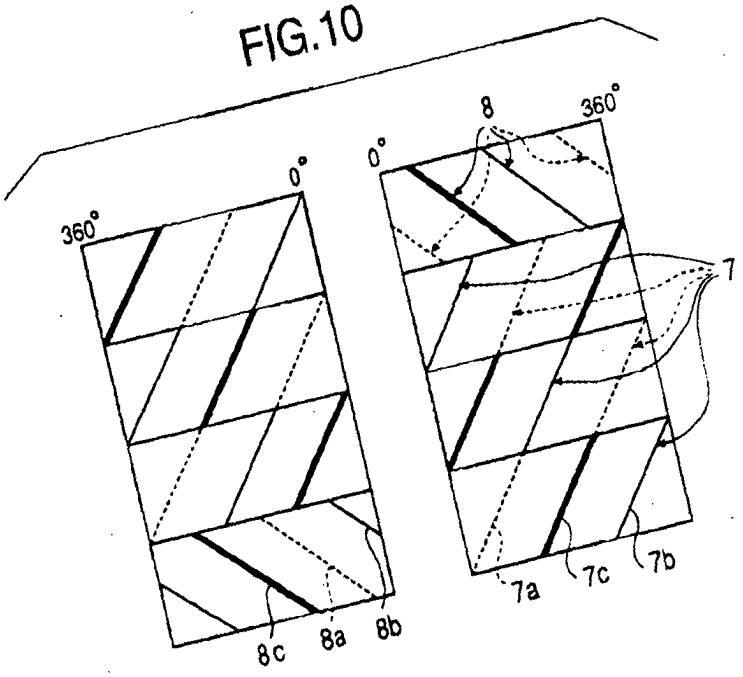


FIG.10



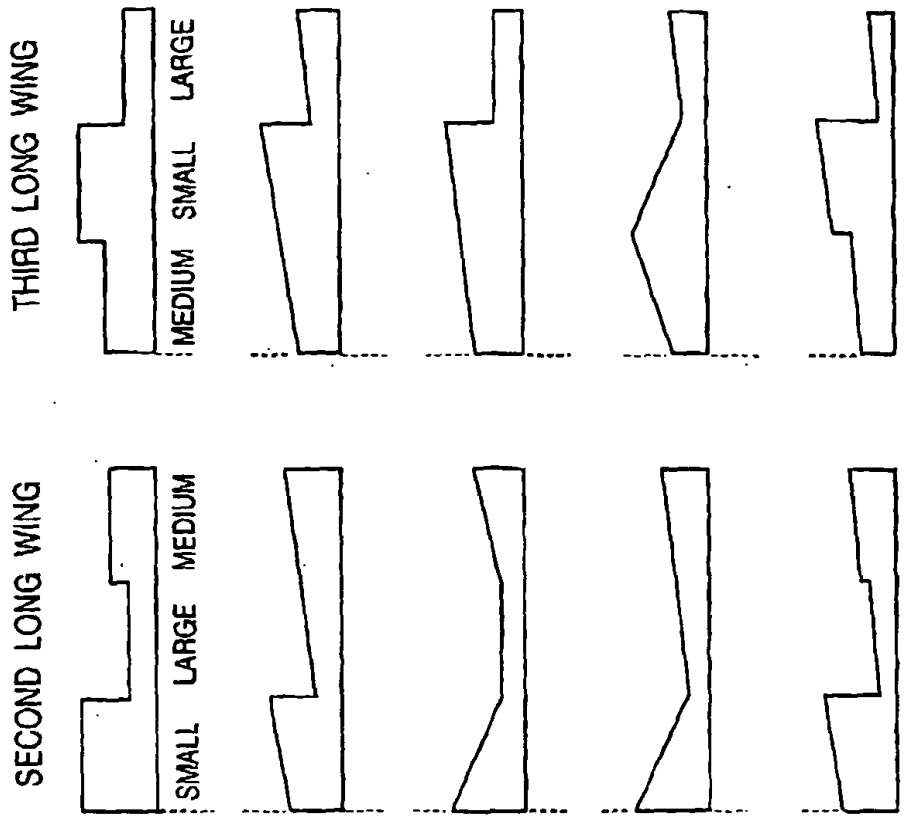


FIG. 11A FIG. 11B FIG. 11C FIG. 11D FIG. 11E

FIG.12

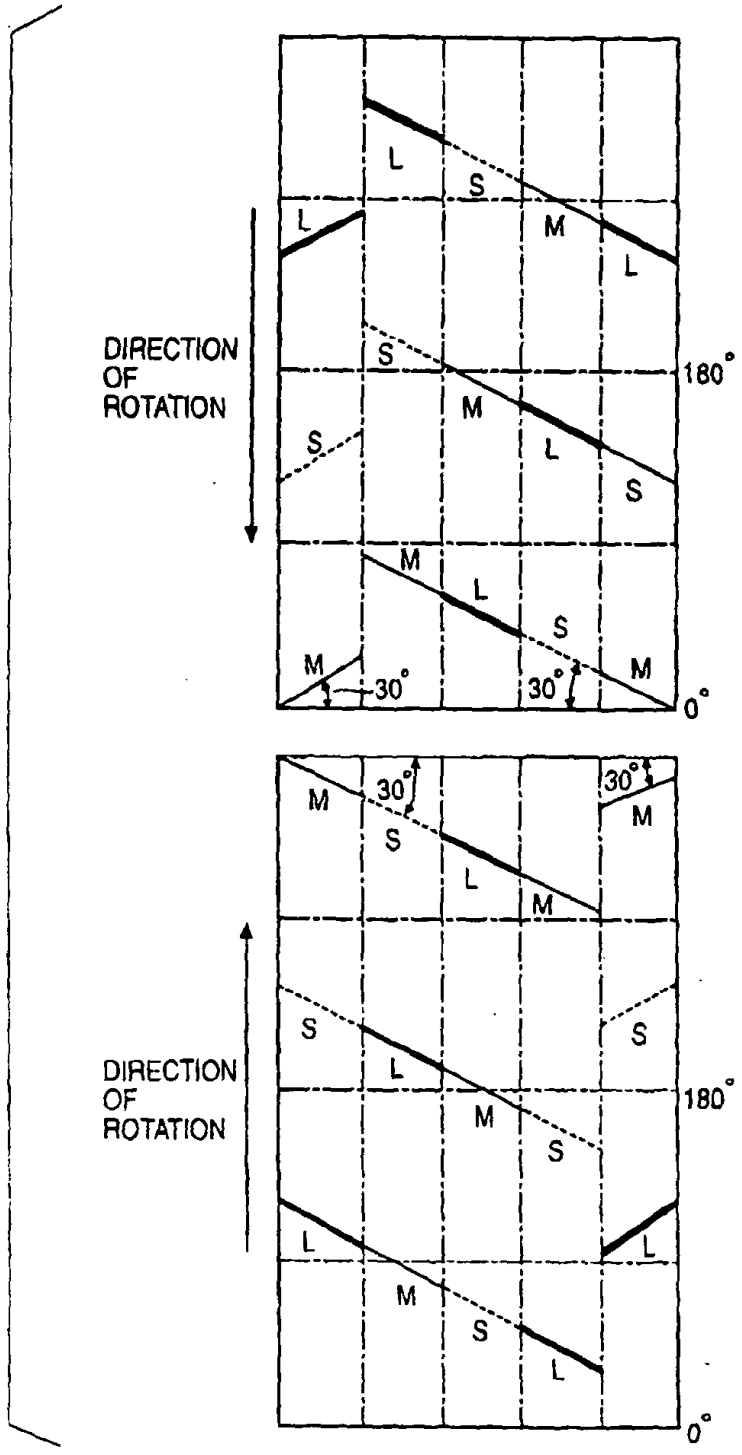

DIRECTION OF ROTATION
180°
0°
30°
DIRECTION OF ROTATION
180°
0°
30°

FIG.13

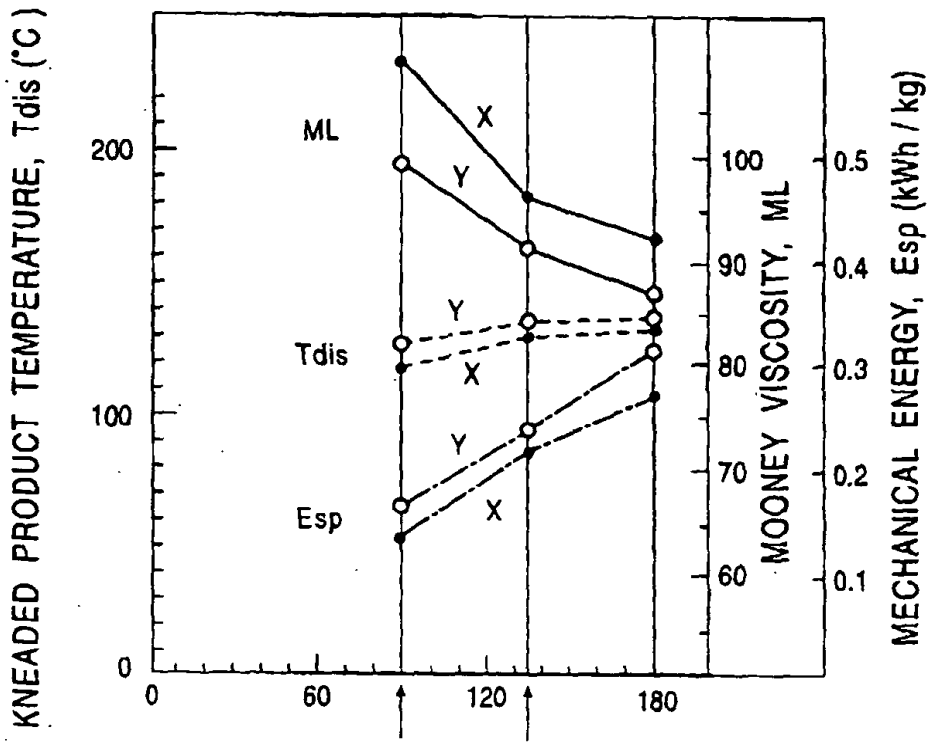
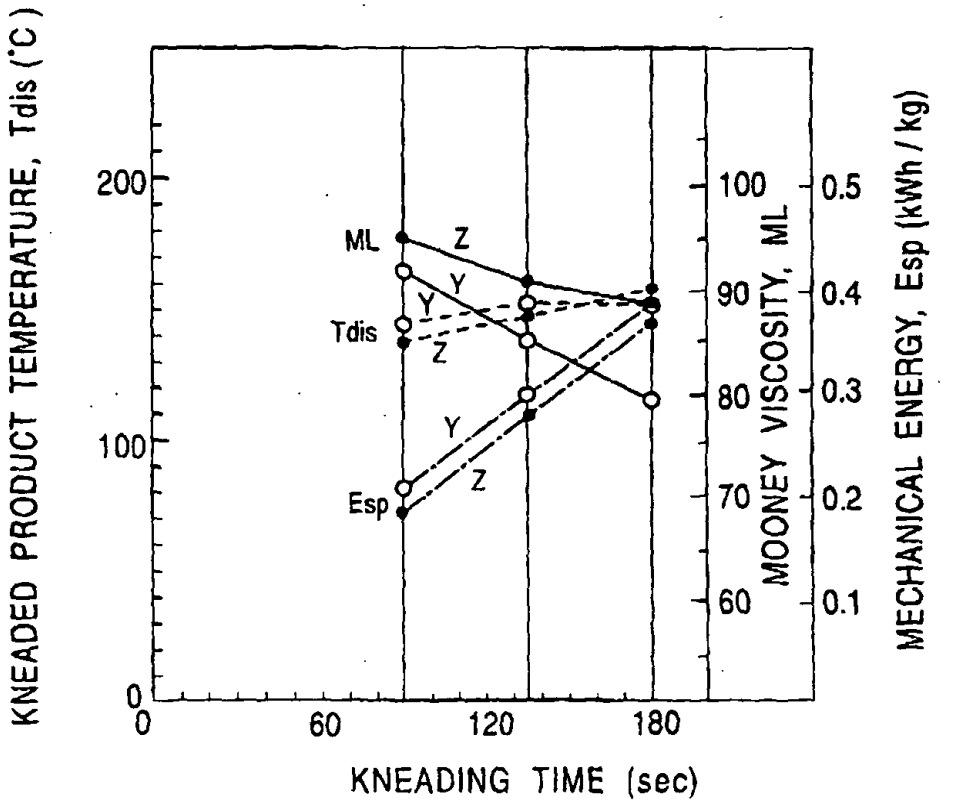
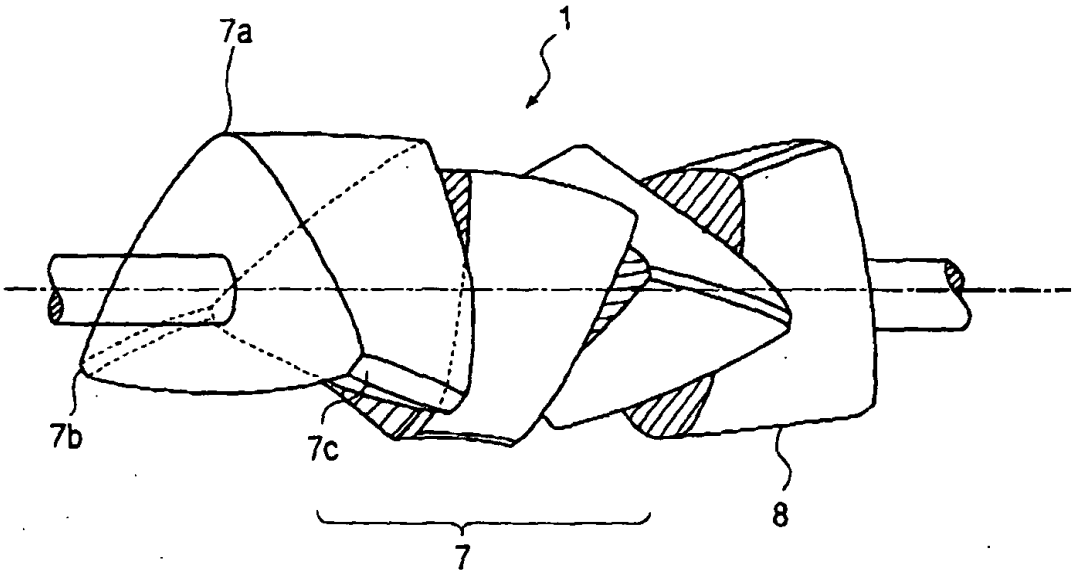


FIG.14



ROTER SPEED N = 90 rpm

FIG.15



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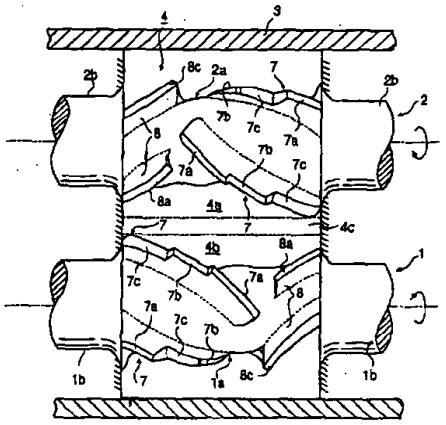
(54) Enclosed kneading apparatus

(57) An enclosed kneading apparatus which can smoothly knead and disperse kneaded products of various kneading conditions without the maintenance of a rotor moving mechanism for a first and second rotors (1,2) and the operation which sacrifices the handling capacity of the kneading apparatus and at the same time, prevent an excessive increase in the temperature of the kneaded products. In the apparatus, the kneaded product of a desired kneading state is obtained by flowing a kneading object in tip clearances between the inner wall of a chamber (4) and a first and second rotors (1,2) while rotating the first and second rotors (1,2) in the chamber (4), and by imparting a shearing force to disperse the kneading object. The respective first and second rotors (1,2) are provided with three long wings (7) in helical fashion each having a plurality of tip portions (7a,7b,7c) for providing a plurality of three tip clearances in the axial direction.

FIG. 1



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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 12 1745

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	US 4 234 259 A (WIEDMANN WERNER ET AL) 18 November 1980 * column 5, line 33-41; figure 6 * * column 5, line 48 *	1-6 8-10	B01F7/08 B29B7/18 B29B7/14 B29B7/16 B29B7/12
X Y	US 4 914 635 A (NISHIGAI KAZUHISA ET AL) 3 April 1990 * column 2, line 47-54; figures 2,3,6 * * claims 1,3,5 *	1,4,7 8,9	
X	US 4 871 259 A (HARADA JUMEI ET AL) 3 October 1989 * column 3, line 29-31; figure 2 *	1,4,7	
X	SU 1 109 317 A (YUROV NIKOLAJ S;KUZNETSOV BORIS G; GRISHKO GRIGORIJ S; GRISHCHENKO PET) 23 August 1984 * line 1-3 *	1	
A	GB 2 124 508 A (UNIROYAL ENGLEBERT GMBH) 22 February 1984 SEE REFERENCE NUMBERS 6 AND 7 * figure 1 *	1-10	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B29B
A	GB 748 197 A (FRANCIS SHAW AND CO LIMITED) * figures 1-7 *	1-10	
Y	US 4 824 256 A (HAERING ERWIN ET AL) 25 April 1989 * column 3, line 64-66; figures 3,12 *	10	
Y	US 4 058 297 A (SEUFERT WILHELM) 15 November 1977 * column 3, line 39; figures 3,4 *	10	
A	US 4 718 771 A (ASAI TOSHIHIRO ET AL) 12 January 1988 * column 3, line 57-; figures 1A,5B,13 *	5,6	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	14 July 1998	Kofoed, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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(54) **Mixing machine.**

(57) A mixer for mixing rubber or plastics compounds. The mixer has a casing (5), and two contra-rotating rotors supported in the casing with their axes of rotation parellel. Each rotor supports two nogs (6,7) of generally helical formation, one nog (6) comprising a single formation and the other (7) comprising two axially spaced formations between which the single formation nog of the other rotor is received as the rotors turn. To improve mixer throughput and efficiency, the radial distance between the radially outer surface of each nog of one rotor and the adjacent surface of the other rotor is substantially greater than the radial distance between the radially outer surface of each rotor nog and the inner surface of the casing, there is an axial gap between the trailing end of the single formation nog of each rotor and the adjacent axial end of the casing, whereby material being mixed can pass through the gap, the minimum gap between the trailing end of any one rotor nog and the leading end of another nog towards which it moves as the rotors turn is substantially greater than the gap between the radially outer surface of the nogs and the casing, and the sides of the nogs adjacent the chamber ends are streamlined to assist the flow of material across their surfaces.

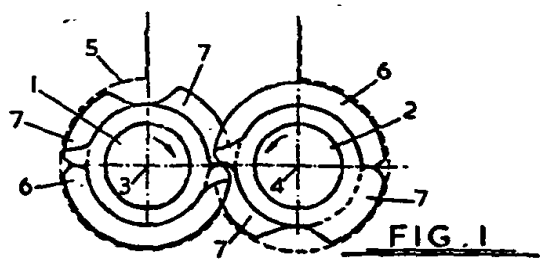

FIG. 1

EP 0 170 397 A1

MIXING MACHINE

The present invention relates to a mixing machine.

Mixing machines are widely used in the rubber and plastics industries to mix together rubber and plastics compounds with appropriate additives such as dyes, plasticisers, cross-linking agents etc. Most mixers currently in use are in accordance with a basic design disclosed in U.S. Patent No. 2 015 618 dated 1935 and c mprise two rotors each supporting raised surfaces or n gs of spiral formation. Two nogs are provided on each rotor, one extending the full length of the rotor, the other being in two axially spaced sections to leave a gap therebetween to accommodate the full length nog f the other rotor. The rotors are mounted in a casing with their axes parallel and rotate in opposite directions. As each rotor turns its nogs sweep across the inside surface of the casing and extend between the nogs of the other rotor to a point adjacent the other rotor's surface. The compound to be mixed is subjected to a combined milling and kneading action as a result of the relative motion of the rotors and the casing surface. To avoid overheating of the compound being mixed the mixing machine is cooled by the circulation of water.

Mixers of the general type described in U.S. Patent N . 2 015 618 have been standard t the rubber and plastics industries for a long time and their

characteristics and design details are well known. It is accepted in the industry that the radial gap between the radially outer surface of each nog and the facing inner surface of the casing is a critical dimension of the machines, and typically this gap has been set at about 7 mm. It has also been accepted practice to endeavour to maintain a gap of the same magnitude between the radially outer surface of each nog and the facing surface of the other rotor, and between the trailing edge of the trailing end of the nog on one rotor and the adjacent leading edge of the nog on the other rotor. When rotors have been used for a prolonged period they become worn, and in particular the portion of the surface of each rotor which faces the radially outer surface of the nogs on the other rotor is worn away. As a result the gap between the nog and the rotor surface increases significantly. Although such rotor wear has been tolerated by some operators of mixing machines this is primarily due to the costs involved in replacing worn rotors. The performance of worn machines has been generally assumed to be suspect.

A further generally accepted feature of the known mixing machines has been the characteristics of the axial ends of the rotor nogs adjacent the axial end faces of the mixer casing. Generally the leading and trailing ends of each helical nog have extended to the

axial ends of the rotor so as to improve the cleaning ffect of the nog ends as they pass across the casing end wall. Furthermore the leading edge of the trailing end of the nogs has often been curved in the direction of rotation so as to improve the scraping effect of the nog on the end wall as shown in U.S. Patent No. 2 015 618. In addition the leading ends of the rotor n gs have been sharply contoured with a leading edge generally parallel to the rotor axis and a straight trailing edge with a view to achieving vigorous working of the compound being mixed and a good scraping ffect between the nog and the casing surfaces. Despite these design features it can be difficult to clean a mixer between mixing batches. This can be a very serious problem, particularly when the colour of successive batches is different, as even small amounts of material from one batch can seriously affect the quality of a subsequent batch.

It is an object of the present invention to obviate or mitigate the above problems.

According to the present invention, there is provided a mixer comprising a casing, two rotors supported in the casing with their axes of rotation parallel, and means for turning the rotors in opposite directions, each rotor supporting two nogs of generally helical formation, one nog comprising a single formation and th other comprising two axially spaced

formations between which the single formation nog of the other rotor is received as the rotors turn, wherein the radial distance between the radially outer surface of each nog of one rotor and the adjacent surface of the other rotor is substantially greater than the radial distance between the radially outer surface of each rotor nog and the inner surface of the casing.

The above arrangement enables the throughput of a machine in terms of weight per unit time to be increased as compared with conventional machines. More material can be mixed in one batch without increasing the mixing time.

Preferably the nog/rotor distance is greater than twice the nog/casing distance, e.g. 15 mm rather than 6.5 mm, although a 3 to 2 ratio or 7 to 4 ratio is also advantageous. The rotor diameter, excluding the raised nogs, may be uniform, but preferably depressions are formed in the rotor surface facing the nogs in the manner of "footprints" beneath the nogs. Preferably the edges of the depressions are smoothly contoured.

The invention also provides a mixer comprising a casing, two rotors supported in the casing with their axes of rotation parallel, and means for turning the rotors in opposite directions, each rotor supporting two nogs of generally helical formation, one nog

comprising a single formation and the other comprising two axially spaced formation between which the single formation nog of the other rotor is received as the rotors turn, wherein there is an axial gap between the trailing end of the single formation nog of each rotor and the adjacent axial end of the casing, whereby material being mixed can pass through the gap.

This arrangement improves the circulation of material and thus makes it easier to dump a batch of mixed material from the mixer and to clean the mixer thereafter, and hence makes it possible to effectively increase throughput. In addition however it appears that this arrangement also enables the volume of material in any one batch to be increased without any increase in mixing time or loss of quality which also of course enhances throughput.

The invention also provides a mixer comprising a casing, two rotors supported in the casing with their axes of rotation parallel, and means for turning the rotors in opposite directions, each rotor supporting two nogs of generally helical formation, one nog comprising a single formation and the other comprising two axially spaced formations between which the single formation nog of the other rotor is received as the rotors turn, wherein the minimum gap between the trailing end f any one rotor nog and the leading end of another nog towards which it moves as the rotors turn is substantially greater than the gap between the

radially outer surface of the nogs and the casing.

This arrangement again results in greater throughput.

The invention also provides a mixer comprising a casing, two rotors supported in the casing with their axes of rotation parallel, and means for turning the rotors in opposite directions, each rotor supporting two nogs of generally helical formation, one nog comprising a single formation and the other comprising two axially spaced formations between which the single formation nog of the other rotor is received as the rotors turn, wherein the sides of the nogs adjacent the chamber ends are stream-lined to assist the flow of material across their surfaces.

This arrangement makes it easier to dump mixed material from the mixer and to clean the mixer after the material has been dumped.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which :

Figs. 1 and 2 illustrate features of the rotors of a conventional mixing machine; and

Figs. 3 and 4 illustrate the corresponding features of an embodiment of the present invention.

Referring to Fig. 1, this is an axial end view of two rotors 1 and 2 which are rotatable in the direction of the arrows about parallel axes 3 and 4 within a casing the walls of which are indicated by

dotted line 5. The casing is open at th top to allow material to be fed in, generally with the aid of a hydraulic ram, and a removable door (not shown) is provided in the casing centrally beneath the rotors to allow mixed material to be dumped from the machine. Each rotor supports two generally helical nogs 6 and 7, one formed by a single raised formation extending the full axial length of the rotor, and the other being formed by two axially spaced formations between which the nog 6 of the other rotor is received as the rotors turn.

Fig. 2 illustrates the rotor surface as it would appear if rolled out flat. It will be appreciated that the nog portions 7 define axially separated parts of a generally helical feature. Each helical nog extends axially the full length of the rotor and extends circumferentially just over half way around the rotor, the lines 8, 9, 10 and 11 being radially spaced by 90° from each other.

Referring now to Figs. 3 and 4, it will be seen that there are four significant differences between the rotor according to the present invention and the conventional rotor.

The first difference is that the shaded areas 12 are milled and ground away to define depressions which are located beneath the "footprints" of the nogs of th other rotor. Thus the minimum radial distance

between the radially outer surface of each nog and the surface of the other rotor is increased by the depth of the depression, e.g., from 6.5 mm to 15 mm. The dotted line in Fig. 3 shows the cross-section of one end of one of the depressions. It will be seen that the edges of the depression are streamlined.

The second difference is that the trailing end 13 of the long nog 6 is cut back so that there is an axial gap of for example 20 mm between it and the end of the rotor and hence the end wall of the casing (not shown).

The third difference is that the nip faces 14 at the adjacent ends of the nogs are ground back to increase the clearance between them, e.g. from 7 mm to 14 mm.

The fourth difference is that the portions 15 of the axial ends of the nogs are streamlined to improve the flow of material past them.

In a mixer of the type illustrated in Figs. 3 and 4 the throughput of material per batch (the batchweight) has been increased by 12 to 17% without any increase in mixing time or loss of quality as compared with a mixer of the type illustrated in Figs. 1 and 2 of the same basic dimensions, that is nog outer diameter 477 mm, rotor body diameter 349 mm, casing internal diameter 490 mm, rotor length 635 mm.

It is sometimes necessary however, to increase th rotor speed by up to 5% to maintain the same mixing

time as with a standard rotor. The power consumption per batch remains the same so that given a larger batch the specific power used (KWH/Kg) is reduced.

The invention has been described in terms of a complete mixing machine including the casing. It will be appreciated however that rotors modified in accordance with the invention may be supplied as replacements for conventional rotors in existing mixing machines rather than as components of complete mixing machines.

The use of local "footprints" or depressions in the rotor bodies to increase the gap between the nogs and the rotor bodies is described above. The whole of the rotor bodies could be of reduced diameter however to achieve the same effect. It is preferred however to use depressions as the cooled surface area of the rotor body is maintained which would not be the case if the whole rotor body was of reduced diameter. Furthermore, as the batch volume is largely determined by the ability of the rotors to take in or pass out material through the rotor nip rather than by the actual volume of the mixing chamber, the use of local depressions provides a greater area of contact between the mix material and the working surfaces of the rotors and mixing chamber by maintaining passageways for the material as shallow as possible.

To achieve adequate internal cooling cavities and

passages and to achieve maximum strength in bending at the rotor/shaft necks a two part shaft shrunk on rotor casting construction is generally used. The use of local "footprint" depressions avoids excessive loop stresses associated with a reduction in rotor diameter over its whole body. The stiffness resisting bending is also maintained.

The above described modification which results in a larger clearance between adjacent ends of the nogs increases the ability of the nogs to draw material into the mixer through the gap between the rotors and this causes an increase in the batch working volume.

The nog end nips form a barrier between the rotors which occurs every 180° of rotation and provides a kneading action which is essential to good mixing. If however the nog end nips are too tight then excessive compression of the mix material can occur and movement of the mix material within the mixing chamber is restricted. This causes increased power consumption and heat generation without contributing to useful mixing.

CLAIMS:

1. A mixer comprisng a casing, two rotors supported in the casing with their axes of rotation parallel, and means for turning the rotors in opposite directions, each rotor supporting two nogs of generally helical formation, one nog comprising a single formation and the other comprising two axially spaced formations between which the single formation nog of the other rotor is received as the rotors turn, wherein the radial distance between the radially outer surface of each nog of one rotor and the adjacent surface of the other rotor is substantially greater than the radial distance between the radially outer surface of each rotor nog and the inner surface of the casing, and/or there is an axial gap between the trailing end of the single formation nog of each rotor and the adjacent axial end of the casing, whereby material being mixed can pass through the gap, and/or the minimum gap between the trailing end of any one rotor nog and the leading end of another nog towards which it moves as the rotors turn is substantially greater than the gap between the radially outer surface of the nogs and the casing, and/or the sides of the nogs adjacent the chamber ends are stream-lined to assist the flow of material across their surfaces.

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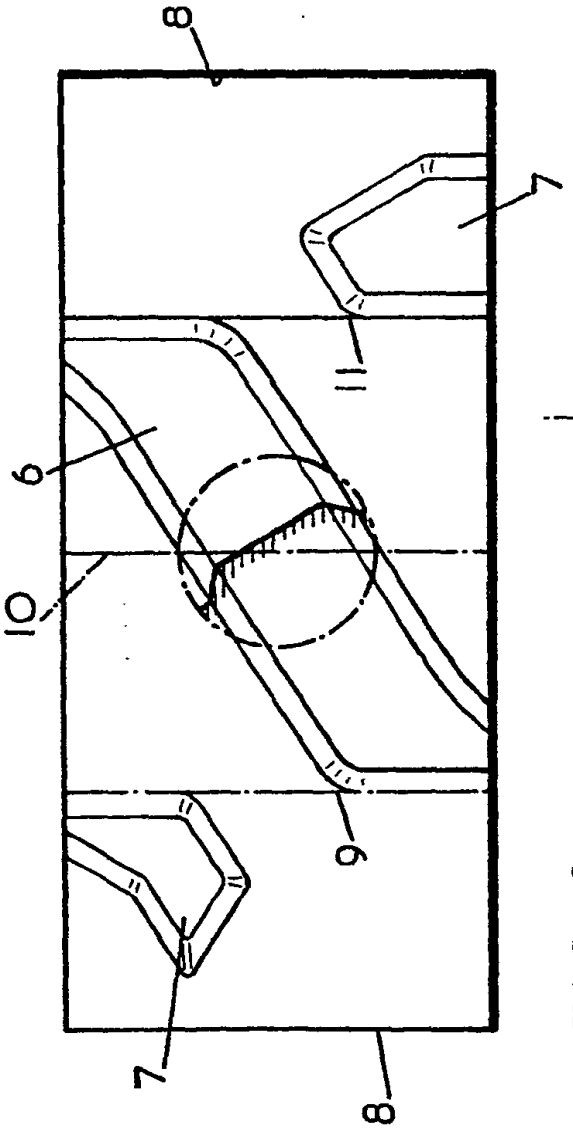

FIG. 2

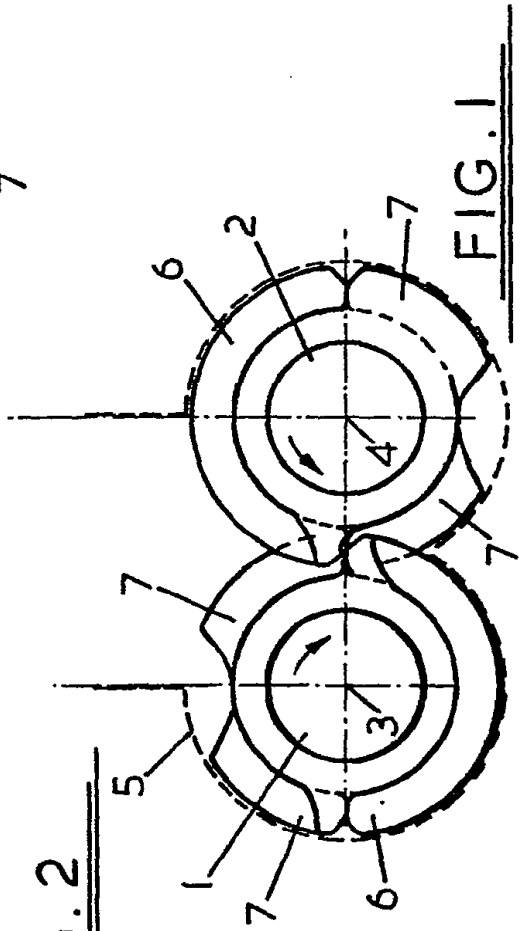

FIG. 1

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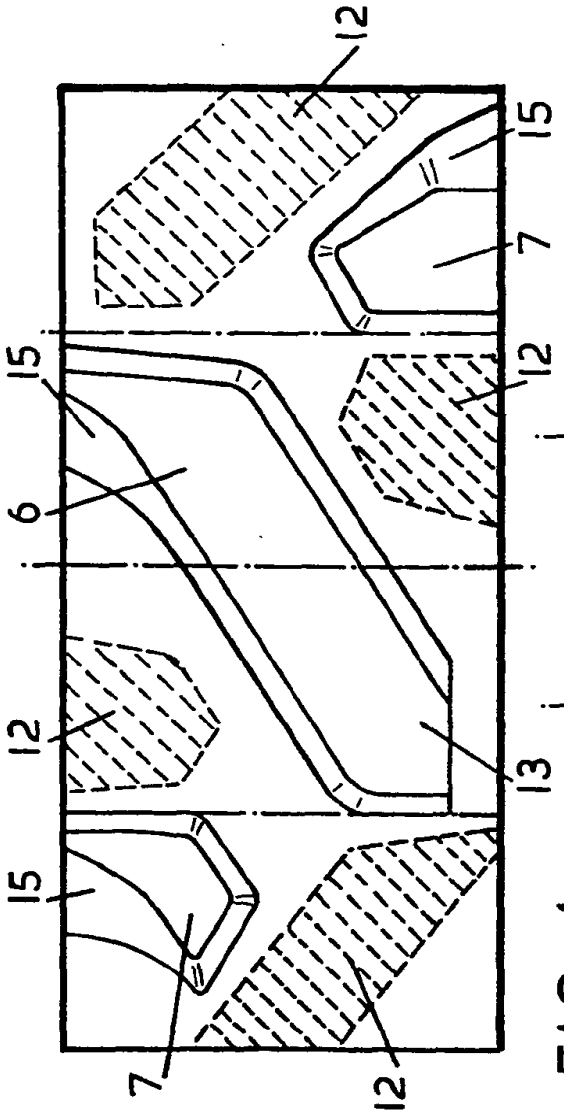

FIG. 4

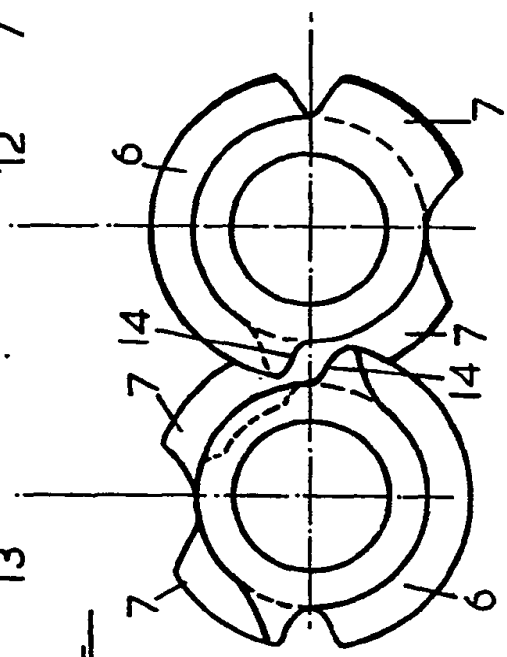

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application number 0170397

EP 85 30 4547

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
A,D	US-A-2 015 618 (COOKE) * Whole document *	1	B 29 B 7/18
A	JOURNAL OF THE INTERNATIONAL RUBBER INSTITUTE, vol. 4, no. 4, August 1970, pages 153-159; P. WHITAKER: "Modern mixing systems" * Page 153, section titled "The intermix"; figures 1,2 *	1	
A	GB-A-2 028 153 (WERNER & PFLEIDERER) * Page 4, lines 34-108; figures 8,9 *	1	
A	US-A-4 284 358 (SATO et al.)		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE-A-1 454 771 (COMERICO ERCOLE)		B 29 B B 29 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20-09-1985	ASHLEY G.W.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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& : member of the same patent family, corresponding document

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EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

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PUBLICATION DATE : 04-06-96

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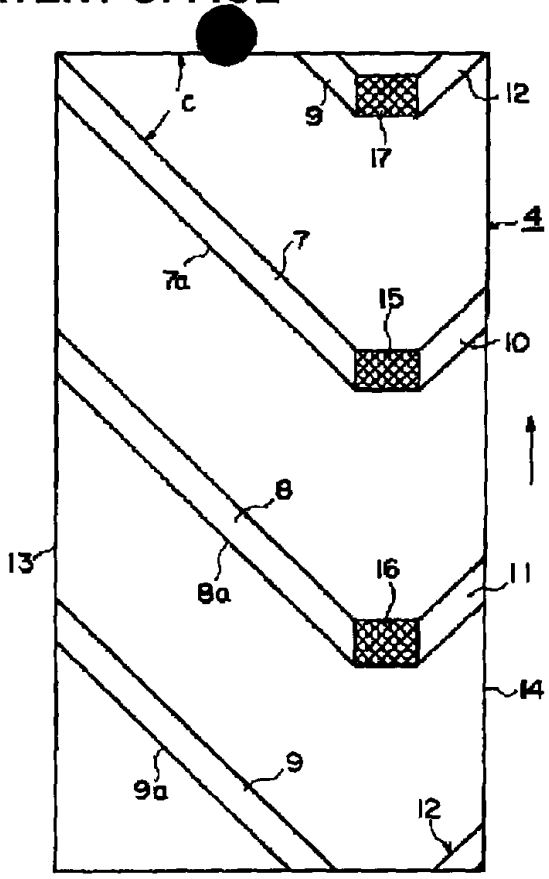
APPLICATION NUMBER : 06280959

APPLICANT : BRIDGESTONE CORP;

INVENTOR : TSUTSUMI HIROBUMI;

INT.CL. : B29B 7/20 B01F 7/02 B01F 7/08 // B29K 21:00

TITLE : ROTOR OF KNEADER FOR RUBBERY ARTICLE



ABSTRACT : PURPOSE: To eliminate the adhesion of rubber to the lower part of the inner peripheral surface of the casing of a kneader while reducing the closing inferiority trouble of a discharge door by reducing the gap between short blades and making the height of a connection part less than that of the short blades.

CONSTITUTION: Long blades 7-9 and short blades 10-12 are respectively provided by two or more so as to be separated from each other at an equal angle and the cut-in angle formed by the rear surfaces 7a-9a in an advance direction of the long blades 7-9 and the tangential line at the outer end of each of the long blades 7-9 is set to 40° or more. The height in the radius direction of the short blades 10-12 of a rotor is set to a degree not exceeding the height in the radius direction of the long blades 7-9. Further, the height in the radius direction of the mutual connection parts 15-17 of the long and short blades 7-9, 10-12 of the rotor is made less than that of the short blades 10-12. By this constitution, the gap between the short blades is reduced to prevent the generation of a deposit to the inner peripheral surface of a casing and rubber passages are ensured to prevent a kneading time from becoming long.

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7 December 2000 (07.12.2000)

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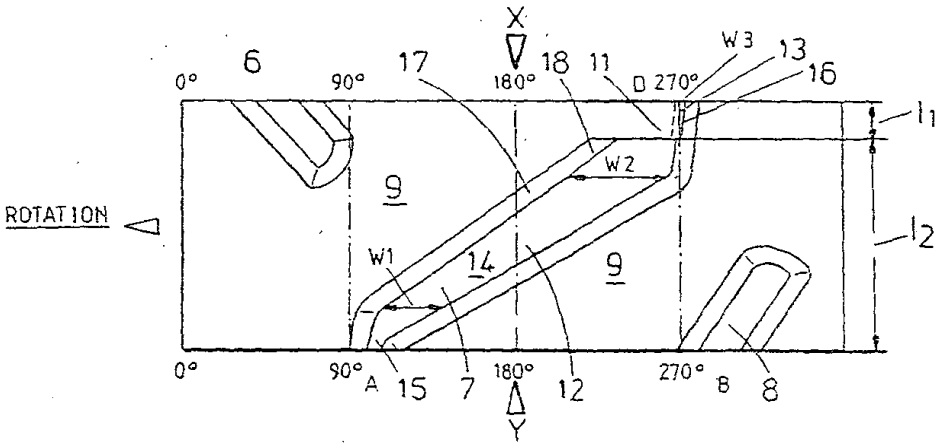
(54) Title: MIXING MACHINES



(57) Abstract: A mixing machine has a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes. The rotors have a helical projection and are rotatable so as to present a leading face of the projection to the material being mixed. The leading face has a discontinuous profile along the axial direction of the rotor so as to define first and second portions. A majority of the leading face (17) of the first portion (12) is concave and a majority of the leading face (19) of the second portion (13) is convex. The circumferential length of a tip (W1, W2) surface of the projection increases in the axial length of the rotor. A clearance defined between the tip of the projection and a facing wall of the mixing chamber decreases in size in the direction of rotation of the rotor. The rotor profiles are designed to provide zones which act on a material to be mixed in different ways so as to improve overall mixing quality and efficiency.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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(74) Agent: EVERY, David, Aidan; Marks & Clerk, Sussex House, 83-85 Mosley Street, Manchester M2 3LG (GB).

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(54) Title: MIXING MACHINES

(57) Abstract: A mixing machine has a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes. The rotors have a helical projection and are rotatable so as to present a leading face of the projection to the material being mixed. The leading face has a discontinuous profile along the axial direction of the rotor so as to define first and second portions. A majority of the leading face of the first portion is concave and a majority of the leading face of the second portion is convex. The circumferential length of a tip surface of the projection increases in the axial length of the rotor. A clearance defined between the tip of the projection and a facing wall of the mixing chamber decreases in size in the direction of rotation of the rotor. The rotor profiles are designed to provide zones which act on a material to be mixed in different ways so as to improve overall mixing quality and efficiency.

MIXING MACHINES

The present invention relates to mixing machines of the kind that are used to mix batches of polymeric compound.

Mixing machines of the kind defined above are typically heavy duty machines used in the mixing of rubber, plastics or other viscoelastic materials exhibiting high viscosity during mixing that may need to be mixed with fillers, oils, colorants and chemical modifiers.

Such mixers comprise two counter-rotating rotors disposed in parallel in a mixing chamber. A pneumatic or hydraulic ram or pusher, the bottom face of which generally forms a top wall of the mixing chamber, forces the material to be mixed towards the mixing chamber and the rotors. The material in the chamber is subjected by contact with the rotors and/or the chamber wall, to a distributive action and to a milling or shearing action which commonly generates heat. The mixed compound is removed from the mixing chamber via a discharge door that is disposed at the bottom of the chamber.

Most mixing machines of this type are based on one of two basic designs. The first and most common is the tangential rotor mixer which was first disclosed in US patent no. 1200070 of October 1916. In such a mixer the rotors are designed to be non-intermeshing so that the loci described by the peripheries of the rotors do not intersect. The compound material to be mixed is compressed and sheared against the internal face of the wall of the mixing chamber in the early part of the mixing cycle whilst the temperature of the compound is still low. This action breaks down and disperses the raw ingredients of the mix but as the temperature increases later in the cycle the viscosity of the mix decreases resulting in less shear and dispersive action but more distributive action. In most machines of this type the rotors are non-synchronous and have a helical profile.

The second type of design is the intermeshing rotor mixer that was disclosed in US patent No. 2015618 dated 1935. In such mixers the loci described by the peripheries of the rotors during rotation intersect. The rotors generally have outwardly extending projections (such as wings or nogs) and rotate synchronously to ensure that

there is no contact between projections on the respective rotors. The projections are generally of a helical configuration and are designed to ensure good distribution of the materials to be mixed early in the mixing cycle. As the temperature increases and the viscosity decreases the mix starts to flow across the projections and dispersion of the materials is effected.

The benefits of each type of mixing machine are well recognised and understood by those skilled in the field. Since there are different phases in a mixing cycle the design of any mixing machine is always a compromise of features to ensure that the discharged mix is of an acceptable standard. Attempts have been made to combine the advantages of each of the two machine types, generally by incorporating features of the tangential machine into the intermeshing type. Such designs have often included the reduction of the leading angle of the helical wing of the intermeshing rotor to force material to flow over the wing earlier in the mixing cycle and to attempt to incorporate the compression or rolling action of the tangential rotor machine into the intermeshing rotor machine.

It is an object of the present invention to mitigate the aforesaid disadvantages of existing mixing technology and to provide for an improved mixing machine.

According to a first aspect of the present invention there is provided a mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends along at least a part of the axial length of the rotor and the rotors being rotatable so as to present a leading face of the projection to the material being mixed, wherein the leading face has a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.

The invention thus exploits the advantages of both conventional tangential (in which the leading face of a wing is convex) and intermeshing (in which the leading face of a wing is concave) rotors.

Each projection may have a tip that defines a surface facing a substantially complementary wall of the mixing chamber, there being a clearance between the surface and the wall.

Preferably both rotors have such a projection and the loci defined by the periphery of the rotors during rotation intersect one another.

The ratio of the axial length of the first portion to the total length of the rotor may be anywhere in the range 0.1 to 0.9 but is preferably 0.6 to 0.8.

The surface of the tip of the first portion preferably increases in circumferential length in the axial direction of the rotor. The ratio of the circumferential length at each end of the first portion may be in the range 1.1 to 10 but is preferably 1.5 to 3.

The circumferential length of the tip of the second portion of the projection is preferably consistent in the axial direction of the rotor and may be between 3% and 50% of the maximum circumferential length of the tip of the first portion but is preferably between 3% and 15%.

The height of the second portion of the projection above the rotor may be lower than or equal to the height of the first portion of the projection. The height of the second portion may be between 25% and 100% of the height of the first portion but is preferably in the range 70% to 90%.

The clearance defined between tip surface and the mixing chamber wall may decrease in the direction of rotation of the rotor by virtue, for example, of the surface being tapered.

According to a second aspect of the present invention there is provided a mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases in the axial direction of the rotor.

According to a third aspect of the present invention there is provided a mixing machine comprising a mixing chamber in which there are disposed at least two rotors

arranged for rotation in opposite directions about respective rotational axes, wherein at least one of the rotors has a projection that extends axially along the rotor, the projection having a tip defining a circumferential surface that forms at least 5% of the circumference of the rotor and is tapered so that the clearance defined between the tip surface and a wall of the mixing chamber decreases in the direction of rotation of the rotor.

A specific embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a section through a mixing chamber of a mixing machine of the present invention;

Figure 2 is a plan view of the unwrapped envelope of a rotor of the mixing machine of figure 1;

Figure 3 is an end view of the rotor in the direction of arrow X of figure 2;

Figure 4 is an end view of the rotor in the direction of arrow Y of figure 2; and

Figure 5 is a cross section through a leading face of a main wing of the rotor of figure 2.

Referring now to the drawings, the exemplary mixing machine is a high-powered, heavy duty machine that is intended for the mixing of rubber and polymeric compounds. The machine has a housing 1 having an internal wall 1a that defines a mixing chamber 2 in which two parallel contra-rotating rotors 3, 4 are disposed. A hydraulically or pneumatically operated ram 5 closes the chamber 2 and, in use, serves to force material towards the rotors 3, 4.

Each rotor 3, 4 is generally cylindrical and has a plurality of helical wings 6, 7, 8 that project radially outward towards the wall 1a of the mixing chamber 2. The wings 6, 7, 8 of one rotor 3, 4 are arranged in such a way that they project into spaces 9 defined between the wings 6, 7, 8 of the adjacent rotor 3, 4 and are disposed such that the loci described by the periphery of the wings 6, 7, 8 of one rotor 3, 4 intersect that of the other during rotation. At the nip defined between the intermeshing surfaces of the two rotors 3, 4 and between the surfaces of each rotor 3, 4 and the chamber wall 1a there is a small clearance 10 through which materials may pass during mixing.

The wings 6, 7, 8 have profiles that have been carefully designed to provide for zones that act on the mix in different ways. A main wing 7 extends helically from a first end of each rotor 3, 4 to the other end and has a discontinuity 11 dividing its profile into first and second axial portions 12, 13. The first portion 12 has an axial length indicated by l_2 and a tip 14 that, after a lead-in formation 15, increases in circumferential length from dimension w_1 to dimension w_2. The second portion 13 has an axial length indicated by l_1 and a tip 16 with constant circumferential length indicated by w_3.

The first portion 12 of the main wing 7 has a leading face 17 whose shape is consistent along its axial length. In cross-section a predominant portion of the leading face 17 extending between the base of the wing 7 and a position near the edge 18 defined at the intersection of the leading face 17 and the tip 14, is concave (represented by 17a in figure 5) with the remainder being planar (indicated by 17b in figure 5) and extending substantially in a radial direction. In contrast, the leading face 19 of the second portion 13 of the main wing 7 has a convex profile. Thus the configuration of the first portion 12 of the wing 7 resembles that of an intermeshing mixer, whereas the profile of the second portion 13 resembles that of a tangential rotor.

The relationship between the dimensions for a particular pair of rotors may be dependent on the particular compound that is to be mixed. The ratio $\frac{l_1}{l_1+l_2}$ could have a value of anywhere in the range 0.1 to 0.9 but it is more likely to fall in the range 0.6 to 0.8. Similarly the ratio $\frac{w_2}{w_1}$ may be in the range 1.1 to 10 but is preferably in the range 1.5 to 3. The ratio of the circumferential length of the second portion 13 of the main wing 7 to that of the adjacent first portion, i.e. $\frac{w_3}{w_2}$, will vary depending on the compound to be mixed but may be in the range 0.03 to 0.5 with a preferred figure of between 0.03 and 0.15.

The dimension w_1 of the wing tip is at least 5% of the circumference of the rotor.

The height h of the second portion of the main wing 7 may be anywhere in the range 25% to 100% of the height of the first portion 12 of the main wing 7 although a preferred figure is likely to be in the range 70% to 90% of that height.

In certain embodiments of the machine the surface of the wing tip 14 of the first portion 12 may be tapered so that the clearance between the tip 14 and the chamber wall 1a decreases in the direction of rotation of the rotor 3,4. The angle of incline of the taper is relatively small subtending an angle of between 1 second and 10 degrees to a conventional rotor concentric surface. The taper is indicated by the change in height t in figure 3.

In use, material to be mixed is introduced into a hopper (not shown) whilst the ram 5 is raised so as to permit the materials to pass into the mixing chamber 2. The ram 5 is then operated to move the material towards the rotors 3,4. After the material has been mixed by the rotors and dispersed it is discharged from an outlet door (not shown) at the bottom of the mixing chamber 2.

At the beginning of the mixing cycle the material is drawn into the nip between the rotors 3,4 and the leading face 17 of the first portion 12 of the main wing 7 ensures rapid ingestion. Initially, the ingested material is relatively hard and flows along the concave leading face 17 of the first portion 12 of the main wing 7 until it encounters the convex leading face 18 of the second portion 13. At this point the material is worked between the second portion 13 of the wing 7 and the wall 1a of the mixing chamber 2 where it encounters a rolling and compressive action which provides a more rapid increase in temperature and reduction in viscosity of the material than occurs along the first portion 12. This temperature increase and viscosity reduction enables the material to flow more easily across the tip 14 of the first portion 12 of the main wing 7 where it is worked between the rotors 3,4 and between the rotors 3, 4 and the wall 1a of the mixing chamber 1 where it is subjected to significant dispersion and shear stress. Material is still caused to flow axially along the concave leading face 17 of the first portion 12 of the main wing 7 and will be subject to some temperature increase and viscosity reduction as it flows along this face. That material which flows over the tip of the wing 7 will move

circumferentially across tip 14 (and tip 16) of wing 7. To maintain constant shear and flow across tip 14 of the first portion 12 of the main wing 7 with this reducing material viscosity, the circumferential width increases from w_1 at the end of the rotor 3, 4 to w_2 at the end adjacent to the discontinuity.

The profile of the second portion 13 of the wing 7 is akin to that of a tangential rotor and serves to provide a rapid increase in temperature of the material so that it is able to flow over the wing tip 14 surface of the first portion 17 much earlier in the mixing cycle.

The taper t on wing tip surface 14 presents a constant compression and shear force to the material in a circumferential direction as the increase in temperature and reduction in viscosity occurs in the material as it passes across face 14 of the first portion 12 of the main projection 7. Without this taper, the reduction in viscosity caused by temperature generated in the material would result in a reducing shear on the material as it passes across the projection.

The subordinate wings 6 and 8 are provided to direct material away from the ends of the chamber and back into the main mixing flow so as to prevent material from apply pressure to dust covers and bearings located at the rotor ends. In existing machines it has been known for material to egress from the machine at these points. The wings 6, 8 also provide a small contribution to the kneading action of the rotor.

By providing rotors with wings having profiles that define separate mixing zones which act on the material to be mixed in different ways the quality and efficiency of the mixing action is improved.

It will be appreciated that numerous modifications to the above described design may be made without departing from the scope of the invention as defined in the appended claims. For example, the leading face of the second portion of the main wing may not be convex along its entire length but may have, for example, a relatively small planar portion. In addition, the taper t is considered a feature that may be used on any form of rotor wing provided the circumferential length of the projection is at least 5% of the rotational circumference of the rotor. Moreover, the

increase in circumferential length of the rotor may be used on rotors that do not have the discontinuity or the tapered wing tip.

CLAIMS

1. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having an axially extending projection and being rotatable so as to present a leading face of the projection to the material being mixed, wherein the leading face has a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.

2. A mixing machine according to claim 1, wherein each projection has a tip that defines a surface facing a substantially complementary wall of the mixing chamber, there being a clearance between the surface and the wall.

3. A mixing machine according to claim 2, wherein both rotors have such a projection and the loci defined by the periphery of the rotors during rotation intersect one another.

4. A mixing machine according to claim 2 or 3, wherein the surface of the tip of the first portion increases in circumferential length in the axial direction of the rotor.

5. A mixing machine according to claim 4, wherein the ratio of the circumferential lengths at each end of the first portion is in the range 1.1 to 10.

6. A mixing machine according to claim 4, where ratio of the circumferential lengths at each end of the first portion is in the range 1.5 to 3.

7. A mixing machine according to any one of claims 2 to 6, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.1 to 0.9.

8. A mixing machine according to any one of claims 2 to 6, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.6 to 0.8.

9. A mixing machine according to any one of claims 2 to 8, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 50% of the maximum circumferential length of the tip of the first portion.

10. A mixing machine according to any one of claims 2 to 8, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 15% of the maximum circumferential length of the tip of the first portion.

11. A mixing machine according to any preceding claim, wherein the height of the second portion of the projection above the rotor is lower than or equal to the height of the first portion of the projection.

12. A mixing machine according to claim 11, wherein the height of the second portion is between 25% and 100% of the height of the first portion.

13. A mixing machine according to claim 11, wherein the height of the second portion is between 70% to 90% of the height of the first portion.

14. A mixing machine according to any one of claims 2 to 13, wherein the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

15. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases along the axial direction.

16. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface that forms at least 5% of the circumference of the rotor and is tapered so that the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

17. A mixing machine substantially as hereinbefore described with reference to the accompanying drawings.

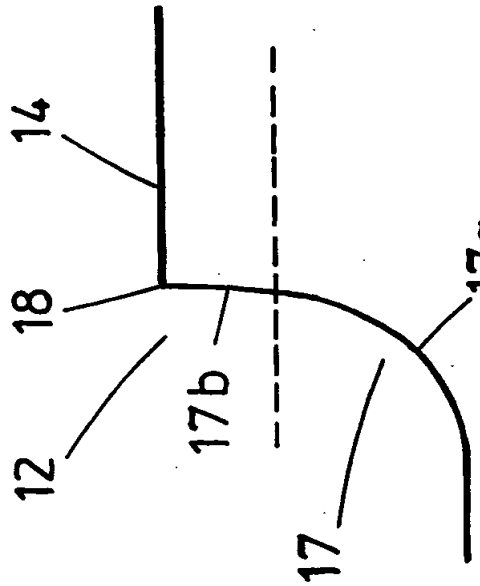

FIG. 5

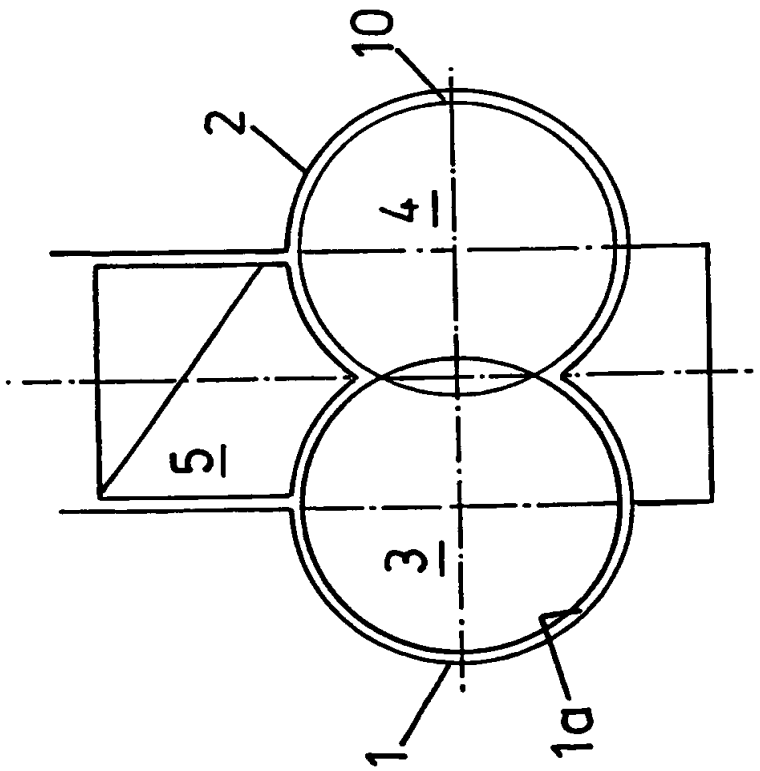

FIG. 1

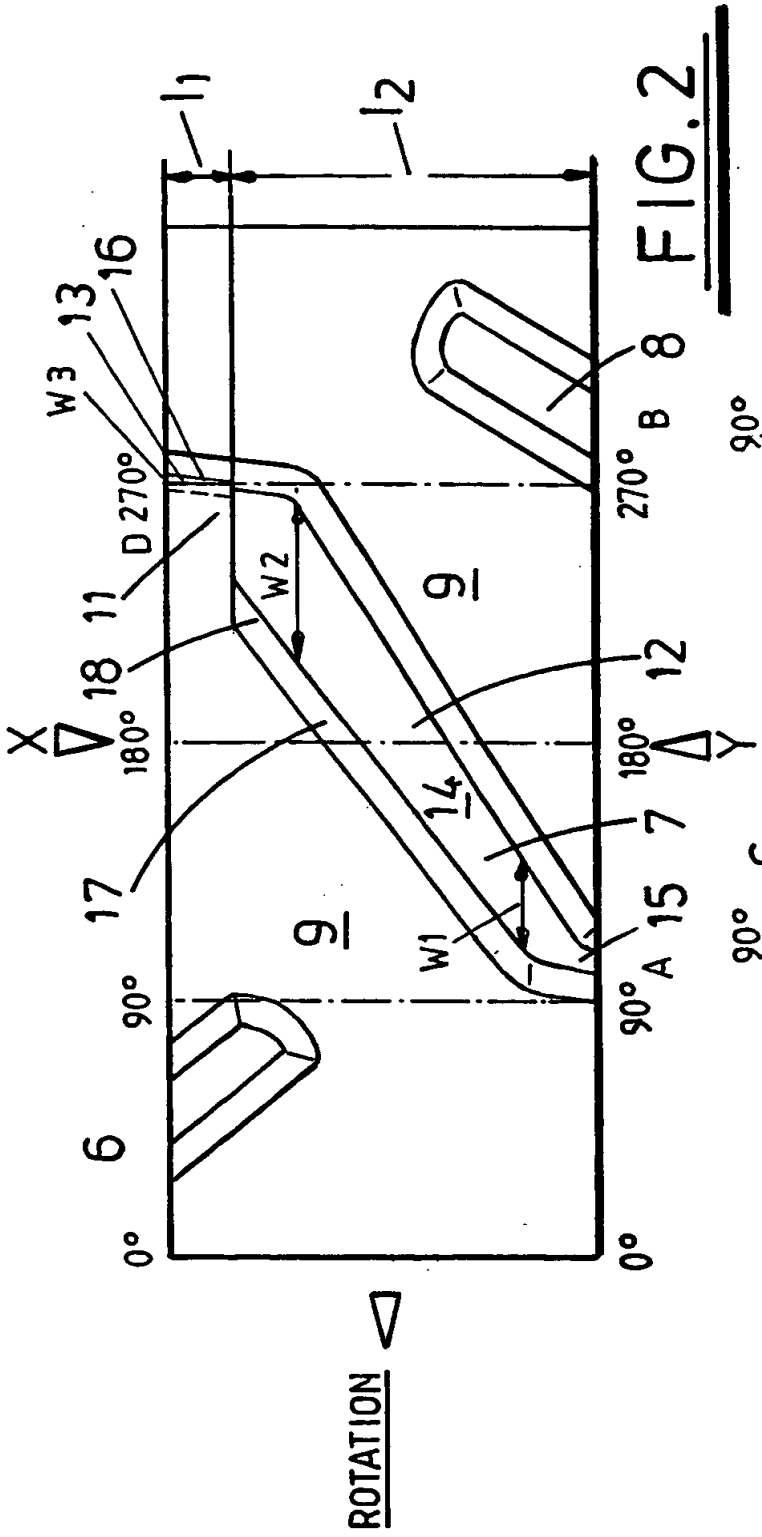

FIG. 2

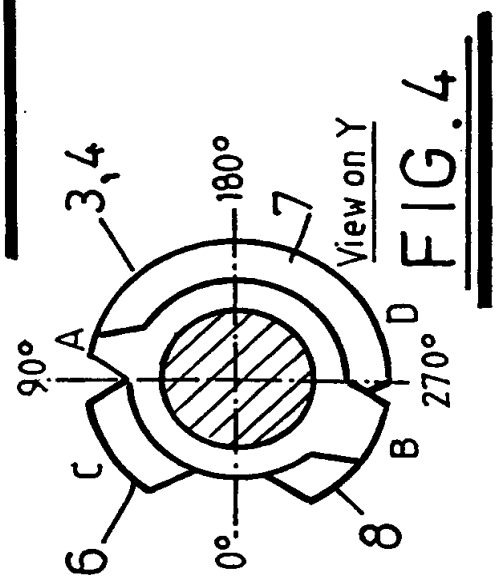

FIG. 4

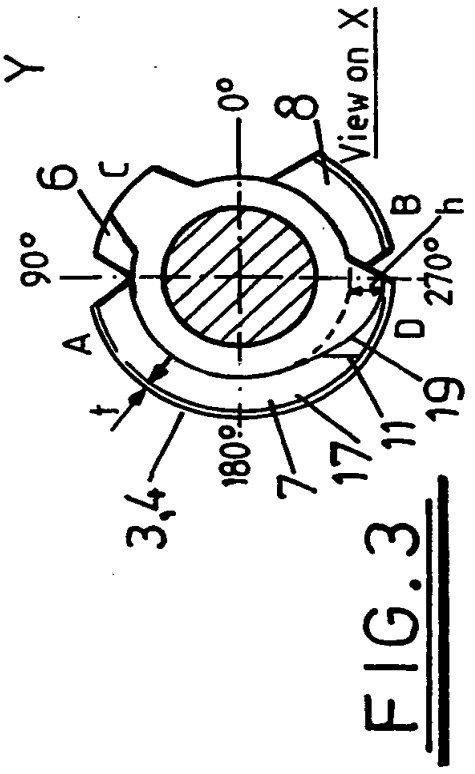

FIG. 3